

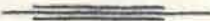
THE MANITOU EXPERIMENTAL FOREST... Its work and aims



ESTABLISHED 1936

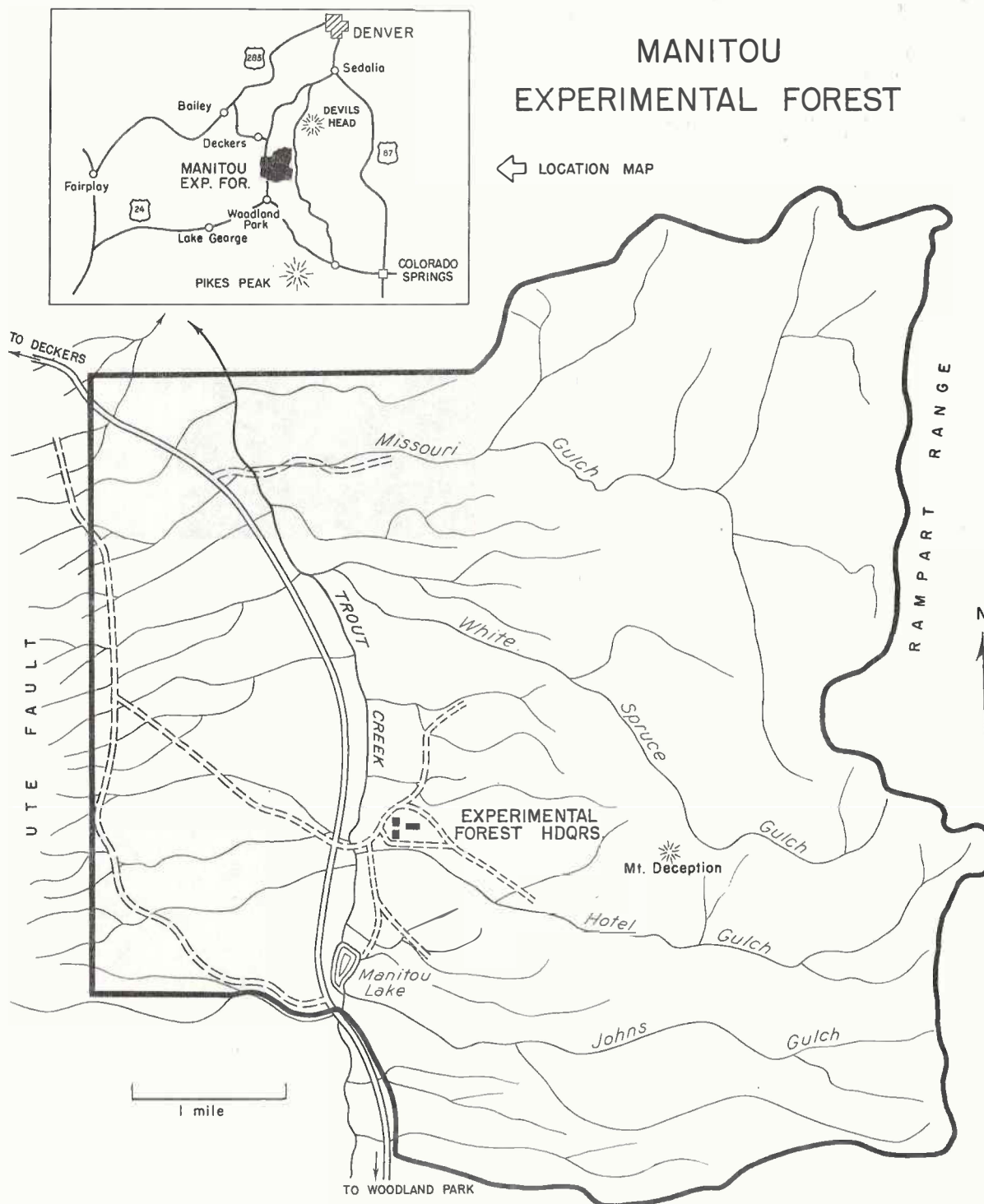
U.S. Department of Agriculture
Forest Service

ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION, FORT COLLINS, COLORADO

—  — W. G. McGINNIES, DIRECTOR —  —

LOCATION

The Manitou Experimental Forest lies 28 miles northwest of Colorado Springs. The experimental area totals 25 square miles, and represents the land of the Front Range. Its general features are shown in the map below.



PURPOSES

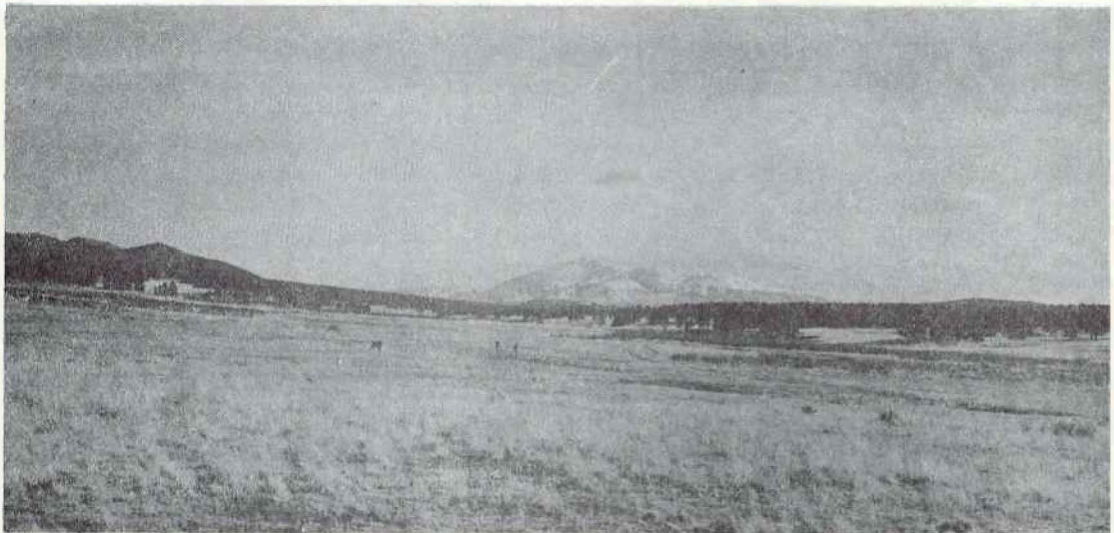
The Manitou Experimental Forest was established in 1936 to study problems of land use as they relate to the management of all the resources of the Front Range. Of economic importance are water supply, recreation, livestock grazing, farming, and timber production. The objective of research work on the Forest is to develop better methods of management to perpetuate or restore the natural resources for long-time productivity. Studies are divided into (1) Range Management, (2) Artificial Revegetation, and (3) Watershed Management.

IMPORTANCE OF PROBLEMS STUDIED

Water supply is the most important subject of research at the Experimental Forest. Water yield from the forested watersheds amounts to 10 to 20 percent of the annual precipitation, or about 1/4 acre-foot per acre. Water is most usable if it is clear, thus the yield of sediment must be considered along with water.

Livestock grazing is another important land use. The parts of the Forest that are suitable for grazing produce forage for beef. Heavy grazing reduces the vegetation cover and bares the soil for accelerated runoff and erosion, which in turn clogs stream channels and reservoirs with sediment.

Recreation, timber production, and farming are less important on the Forest. Elsewhere in the Front Range these uses of land furnish a living for many local residents.



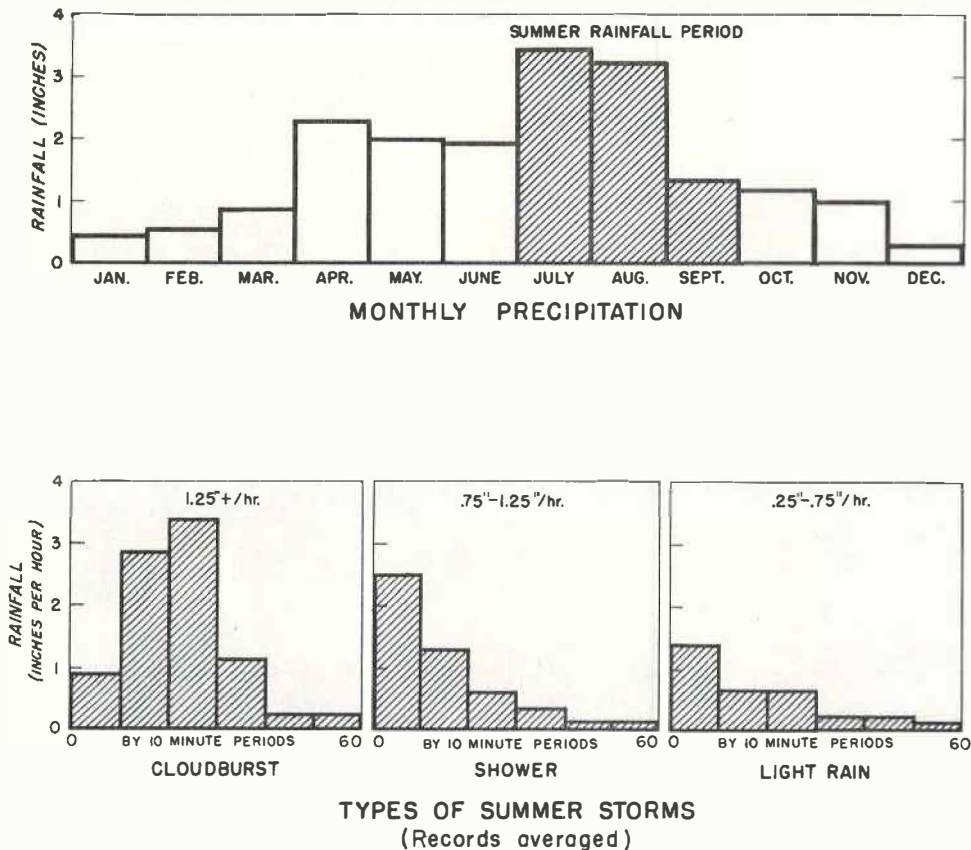
Trout Creek with Pikes Peak in background
Manitou Experimental Forest

RESEARCH WORK

Because various kinds of land use are studied on the Experimental Forest, coordination of effort is important. Under the direction of the Rocky Mountain Forest and Range Experiment Station at Fort Collins, Colorado, resident technicians undertake research work in range and watershed management. Several college students in forestry are selected each year as summer assistants. Nearby residents are cooperators in many of the research studies. Every other year a field day is held as an "Open House," with a special opportunity for public discussion of the research program.

CLIMATE

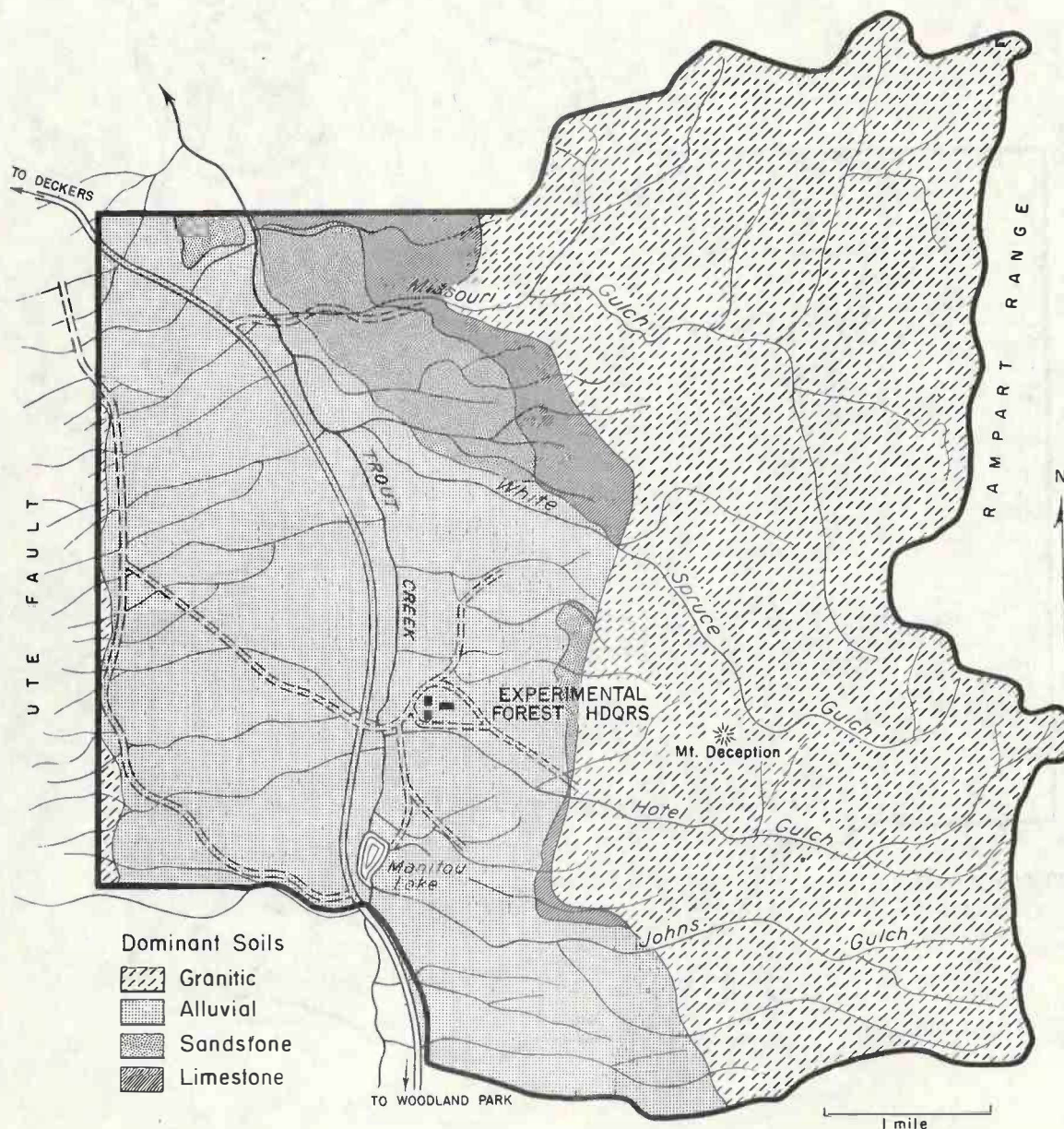
The climate is mild, with an average yearly temperature of about 45 degrees. The mean monthly temperature for January is 27 degrees; for July, 60 degrees. On the average there are 113 days in the growing season, the frost-free period extending from May 28 to September 18. Annual precipitation averages about 17 inches; of this, 58 percent occurs during the growing season. Yearly precipitation has varied from 8 inches to 26 inches.



TOPOGRAPHY AND SOILS

The Experimental Forest includes broad, gently rolling valleys and plateaus, and rugged mountains with narrow, steep-walled canyons. The elevation ranges from 7,500 to 9,500 feet. Granitic soils of low fertility and high erodibility occur in the rough eastern part. Alluvial soils formed by stream outwash are of medium fertility and occupy the level portions. Limestone soils, which are the most productive, and sandstone soils also are found in small areas of the Forest.

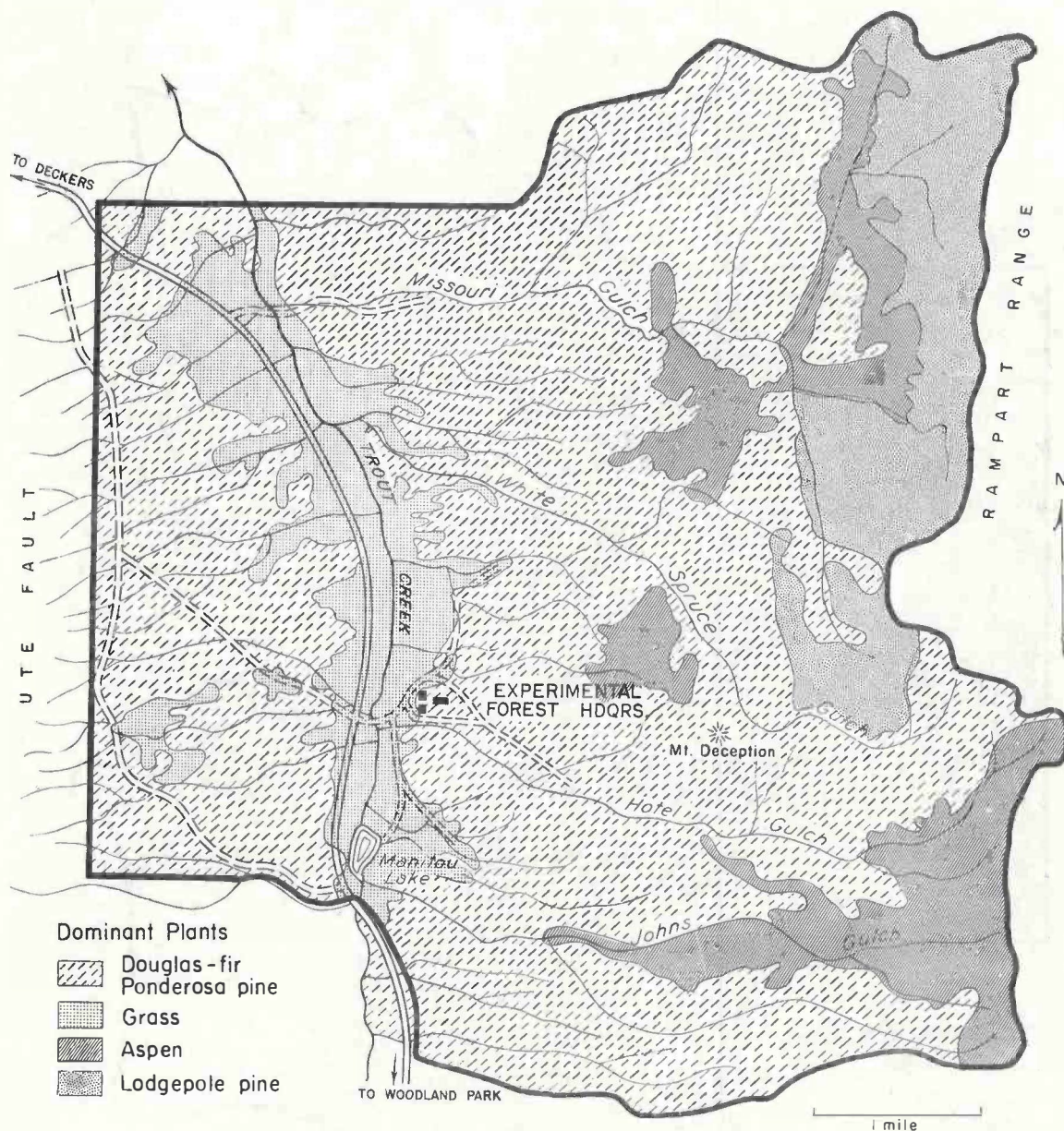
Examples of geologic and accelerated erosion are found throughout the Forest. The general distribution of the soils is shown below.



NATIVE VEGETATION

The native vegetation is typical of ponderosa pine forests in the southern Rocky Mountains. Ponderosa pine, Douglas fir, lodgepole pine, and aspen are the important tree species. Bunchgrasses make up most of the grass vegetation. The most common are Arizona fescue and mountain muhly. Shrubs may be seen occasionally throughout the timbered areas.

The Experimental Forest has been grazed by livestock and logged. Below is a map showing the general distribution of the native vegetation.

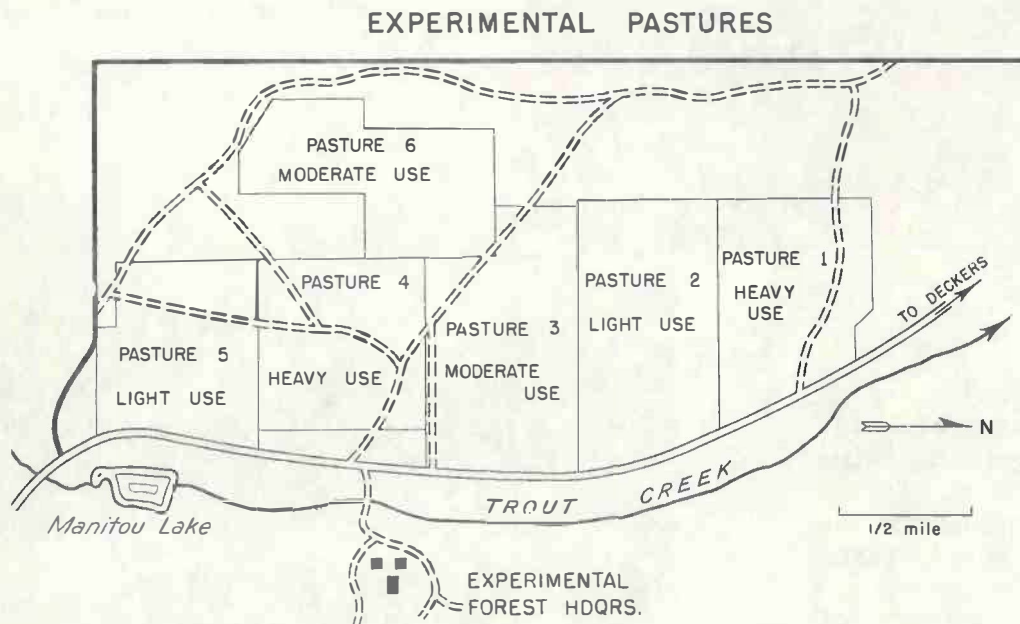


RANGE MANAGEMENT

PASTURE STUDIES

Since 1942 yearling Hereford heifers furnished by local ranchers have been grazed for a 5-month season, June 1 to October 31, on six pastures of about 300 acres each. Three rates of stocking representing heavy, moderate, and light use of the vegetation have been studied. The stocking rates of the pastures are:

<u>Heavy</u>	- 57 percent of annual herbage removed
<u>Moderate</u>	- 33 percent of annual herbage removed
<u>Light</u>	- 14 percent of annual herbage removed

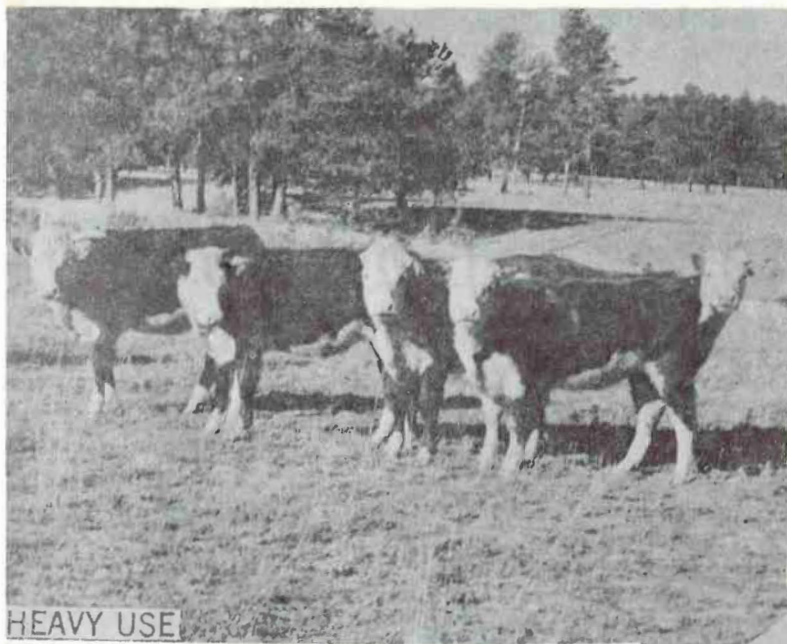


PRIMARY OBJECTIVES

Good cattle
Good range
Good watersheds

Best economy
for all
in the long run

PASTURE STUDIES



Stocking rate based on 57% herbage removed. Heavy grazing reduces annual forage production, depletes the grass stand, gives poor cattle gains, and a gross return of \$1,874 per section

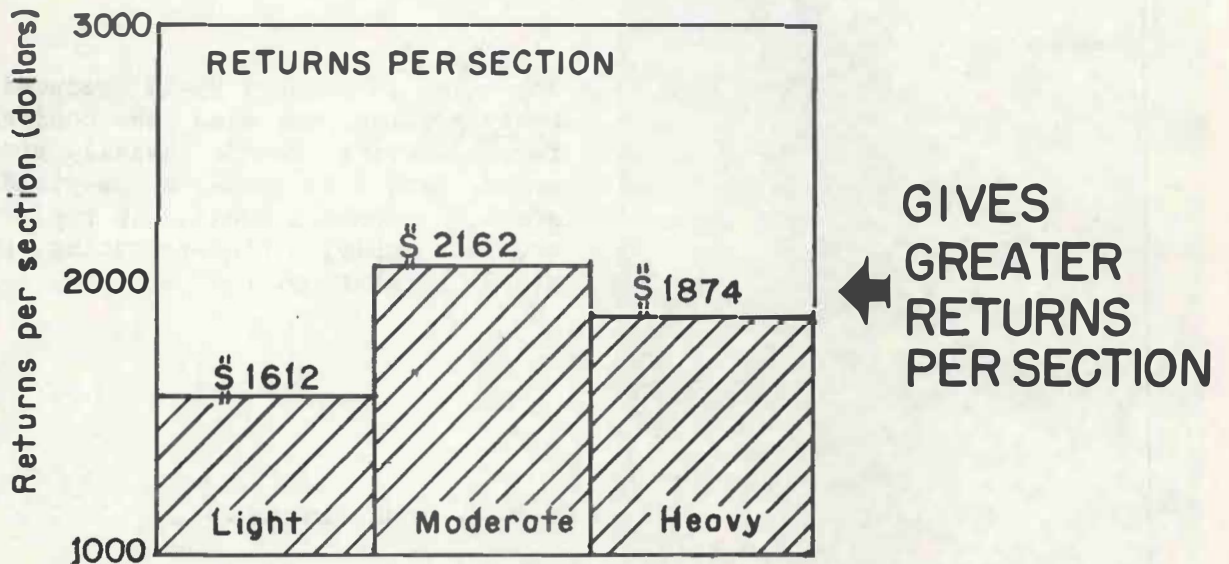
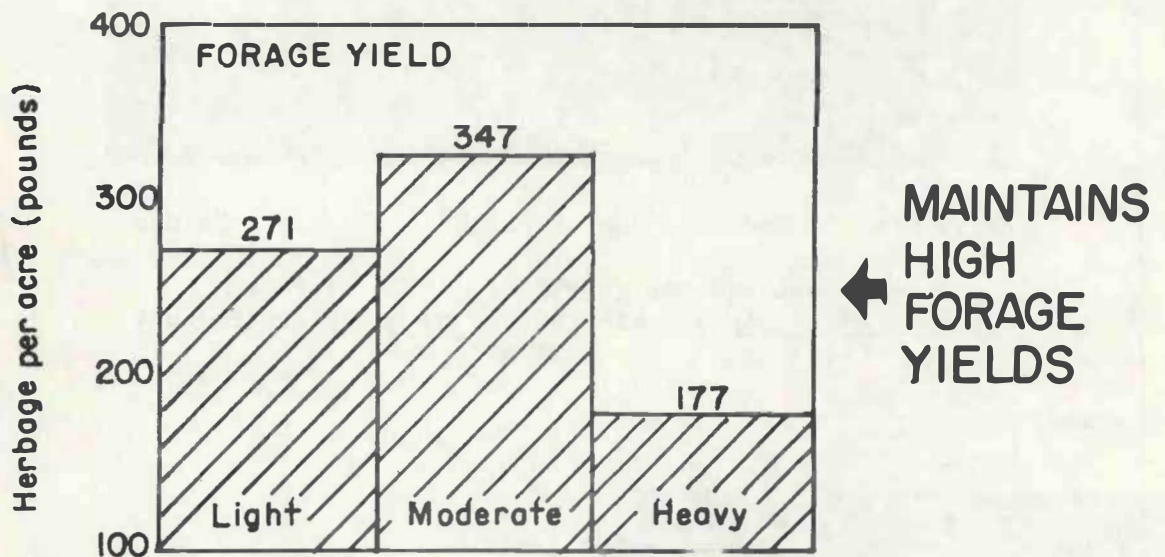
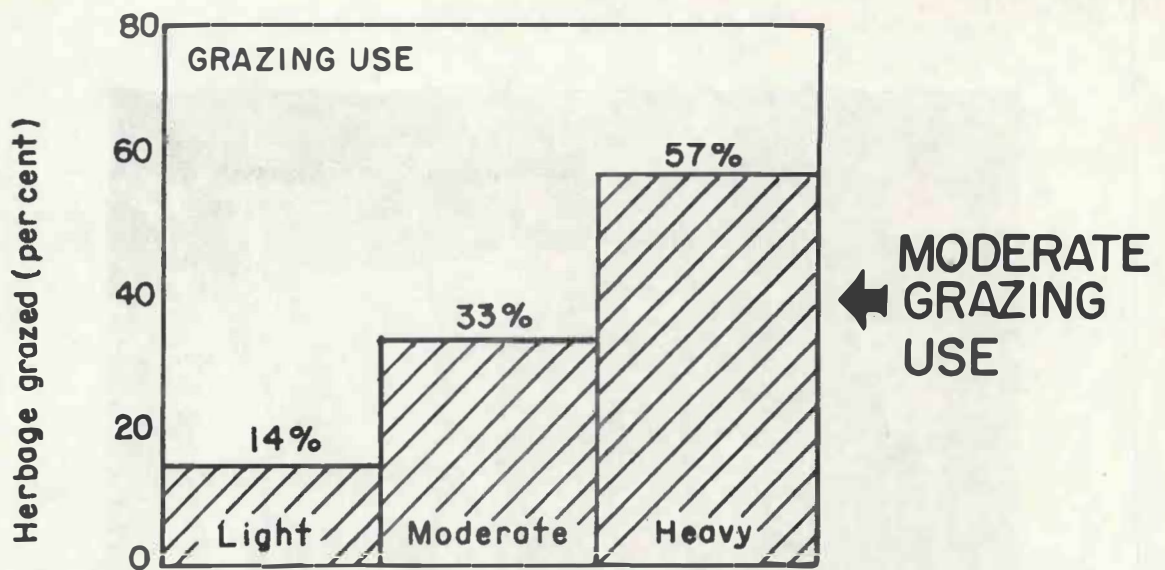
Stocking rate based on 33% herbage removed. Moderate grazing maintains annual forage production, improves the grass stand, gives good cattle gains, and a gross return of \$2,162 per section



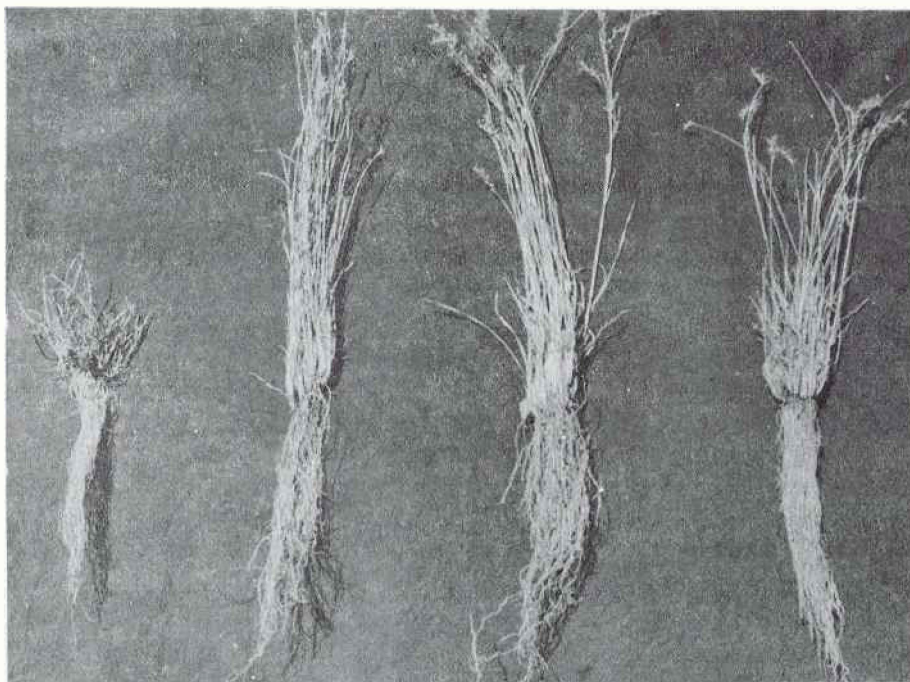
MODERATE USE



Stocking rate based on 14% herbage removed. Light grazing improves annual forage production, increases the grass stand, gives high cattle gains and a gross return of \$1,612 per section



PLANT GROWTH



Heavy use

Moderate use

Light use

No use

Both root and top growth of little bluestem (*Andropogon scoparius*) are reduced by heavy grazing use

Blue grama



Not only is herbage yield reduced by heavy grazing, but also less desirable forage species invade heavily grazed areas. Here blue grama, a low-yielding grass in mountain areas, is replacing mountain muhly, a high-producing, palatable bunchgrass.

← Mountain muhly

ARTIFICIAL REVEGETATION

In addition to learning how to manage native pastures it is also necessary to learn how to heal the scars of past abuse. Methods of artificial revegetation of abandoned farm lands and depleted range lands are tested. The objectives are to (1) increase forage production, and (2) stabilize eroding soil. The first step is to find out what plants will grow best in the Front Range areas.



Row plots where 130 grasses, legumes, and shrubs have been tested for adaptability



The best species from the nursery trials are then tested in field plots at many different locations to determine which are best suited for different elevations and sites.

A 1-year-old stand of intermediate wheatgrass seeded on depleted range land in South Park. The seedbed was prepared with a moldboard plow followed by packing and drilling.

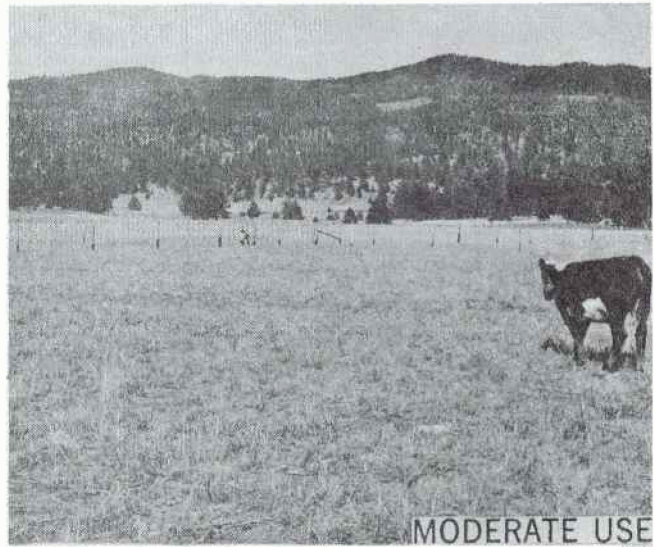
PASTURE STUDIES

Small pastures of crested and intermediate wheatgrasses, Russian wild-rye, and smooth brome are being grazed at heavy, moderate, and light intensities.

SMOOTH BROME



HEAVY USE



MODERATE USE

Reseeded grasses are not miracle grasses. They can be destroyed by too heavy grazing. Grazing smooth brome to a 2-inch stubble will weaken the plants' vigor and cause lower production

Livestock gains, herbage yields, and beef production show clearly the advantages of successful reseeding

Reseeded pasture	: Herbage yield : Lbs./acre	: Heifer days : grazing : Per acre	: Gain per day : Lbs.	: Total gain : Lbs./acre
Smooth brome	1,399 (4 yrs.)	42 (3 yrs.)	1.5 (3 yrs.)	65 (3 yrs.)
Crested wheatgrass	1,959 (4 yrs.)	44 (3 yrs.)	1.6 (3 yrs.)	77 (3 yrs.)
Intermediate wheatgrass	1,668 (2 yrs.)	47 (1 yr.)	1.7 (1 yr.)	84 (1 yr.)
Mixture: crested wheatgrass, smooth brome, sweet clover	2,471 (4 yrs.)	47 (3 yrs.)	1.7 (3 yrs.)	91 (3 yrs.)
Russian wild-rye	409 (1 yr.)	Grazed for first time in 1951		

ADAPTABLE GRASSES

SMOOTH BROME: Widely known, widely used. Good spring and summer pasture. Not as productive as other grasses. Prefers moist ground.



CRESTED WHEATGRASS: Also widely known and used. Excellent spring pasture and hay crop. High production, more resistant to grazing than smooth brome.

INTERMEDIATE WHEATGRASS: A newer importation from the old world. Excellent spring and summer pasture, good hay crop, and high seed production.



RUSSIAN WILD-RYE: Another newer importation. Low producer, but excellent early spring pasture. Ready for grazing 2 to 3 weeks earlier than crested wheatgrass.



BLUEBUNCH WHEATGRASS: Native to United States. Slower and more difficult to establish than other grasses, but makes excellent summer pasture.

BIG BLUEGRASS: Native to United States. Excellent late - fall, early winter pasture. Has had 8 to 10 inches green growth at the Experimental Forest in late December.



WATERSHED MANAGEMENT

STREAM FLOW

Since 1939 stream flow, precipitation, and ground water records have been taken in the 4,800-acre Missouri Gulch watershed. These records provide knowledge of various storm patterns occurring on the watershed and their influence on stream flow and erosion. The watershed is grazed by livestock.

PLANT COVER

Records of precipitation, runoff, and erosion have been kept since 1939 on six small ponderosa pine watersheds of 1 to 2 acres in size. Recently, two watersheds have been cut and burned to encourage the growth of aspen and two to develop a grass stand, while two were left unchanged. These watershed studies will give clues as to which type of vegetative cover is superior in managing a watershed.

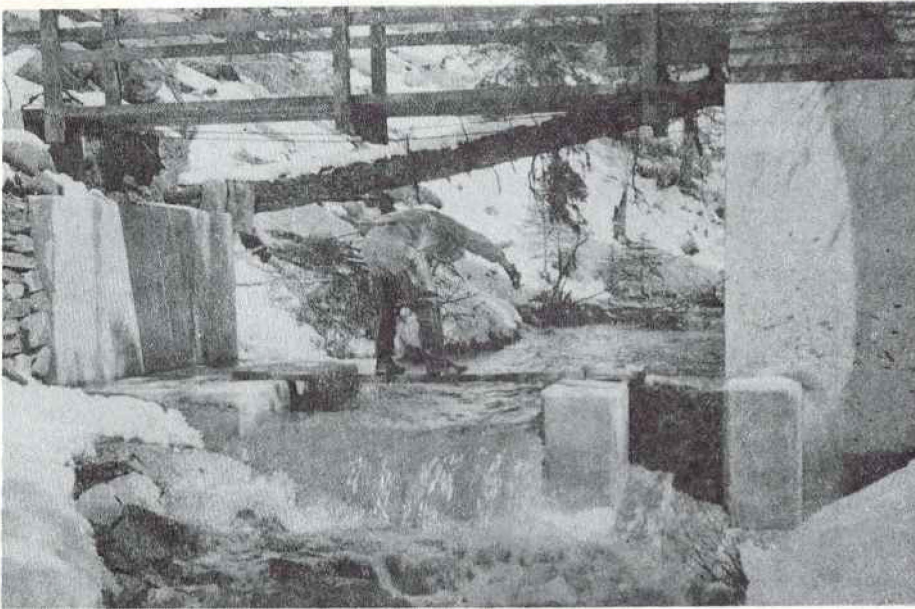
SEDIMENTATION

Gully erosion and bank sloughing yield the greatest amount of sediment to stream channels. A sedimentation study has been made of Manitou Lake. Gully and sheet erosion studies have been made on the experimental pastures. Erosion and sediment-yield characteristics of the soils have been determined.



Sediment bars in the South Platte River move downstream at the rate of $1\frac{1}{2}$ miles per year and are erosion depositions from steep slopes, gullies, and roads.

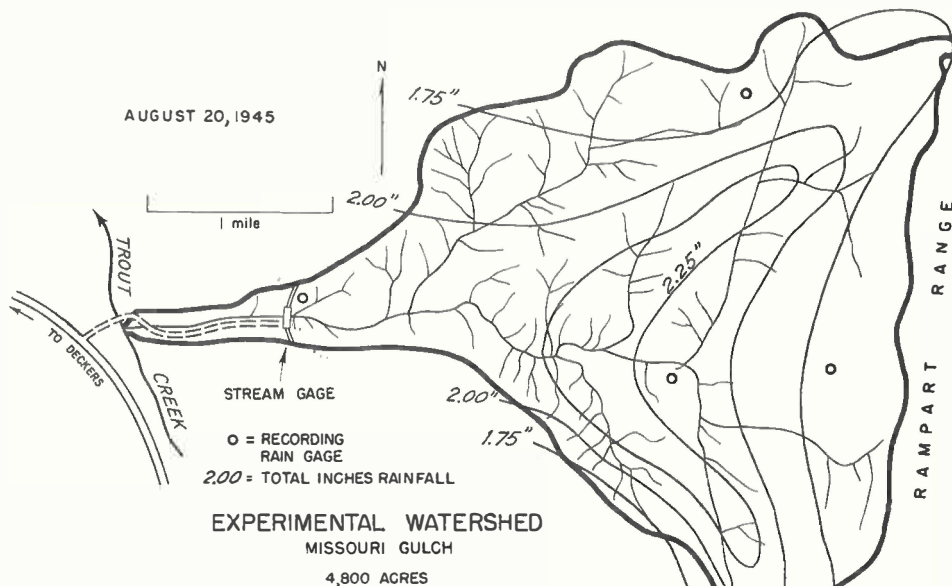
STREAM FLOW



Missouri Gulch
stream gage
during
high spring
flow

A MISSOURI GULCH STORM

High runoff from cloudburst storms is related to storm distribution, total precipitation, and stream flow at the time of the storm (antecedent flow). High antecedent flow indicates a low watershed capacity to store additional rain water. Storage capacity is influenced by vegetation which promotes water absorption.

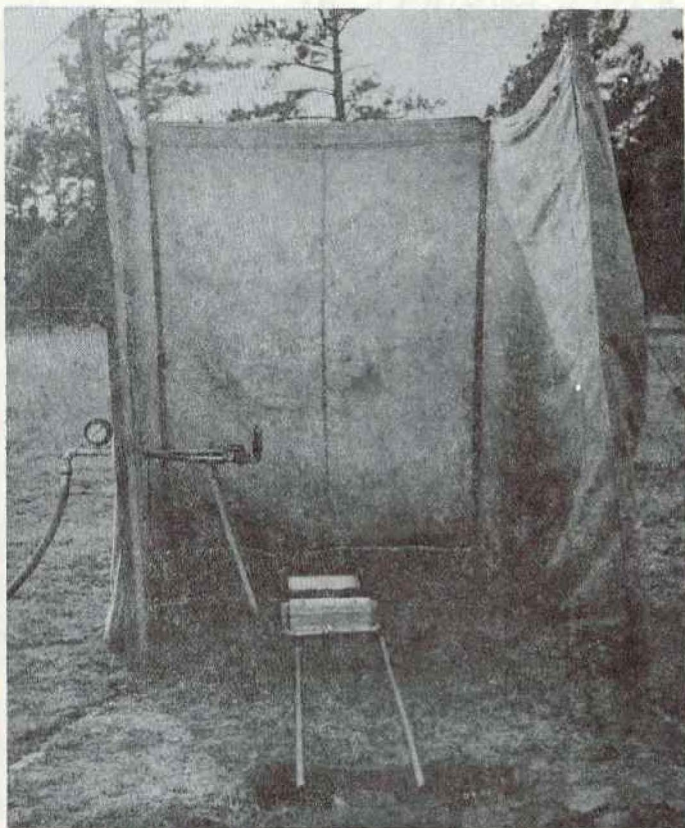


NOTES

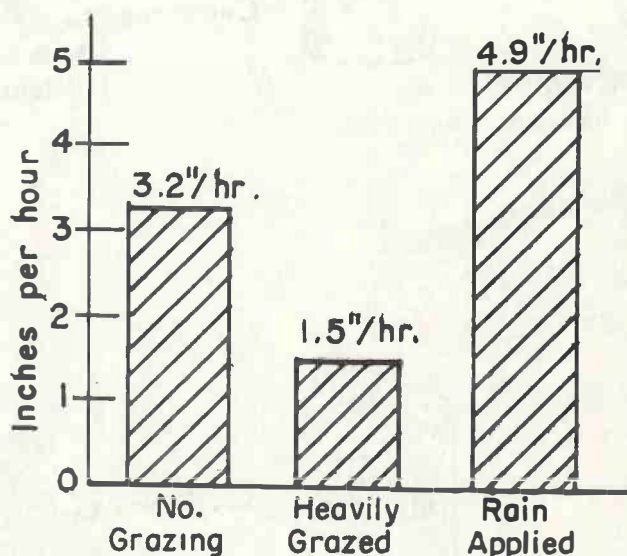
Watershed area	4,800 acres
Total precipitation	2.03 inches
Volume water produced	776 acre-feet
Volume runoff water	216 acre-feet
Runoff	28 percent
Peak flow	107 c.f.s.
Daily antecedent flow	16 acre-feet

WATER ABSORPTION

Grazing changes the water-absorbing capacity of the soil. Tests by applying artificial rainfall to small plots scattered in the six pastures have established this fact. The rates of water absorption decrease as grazing becomes heavier.

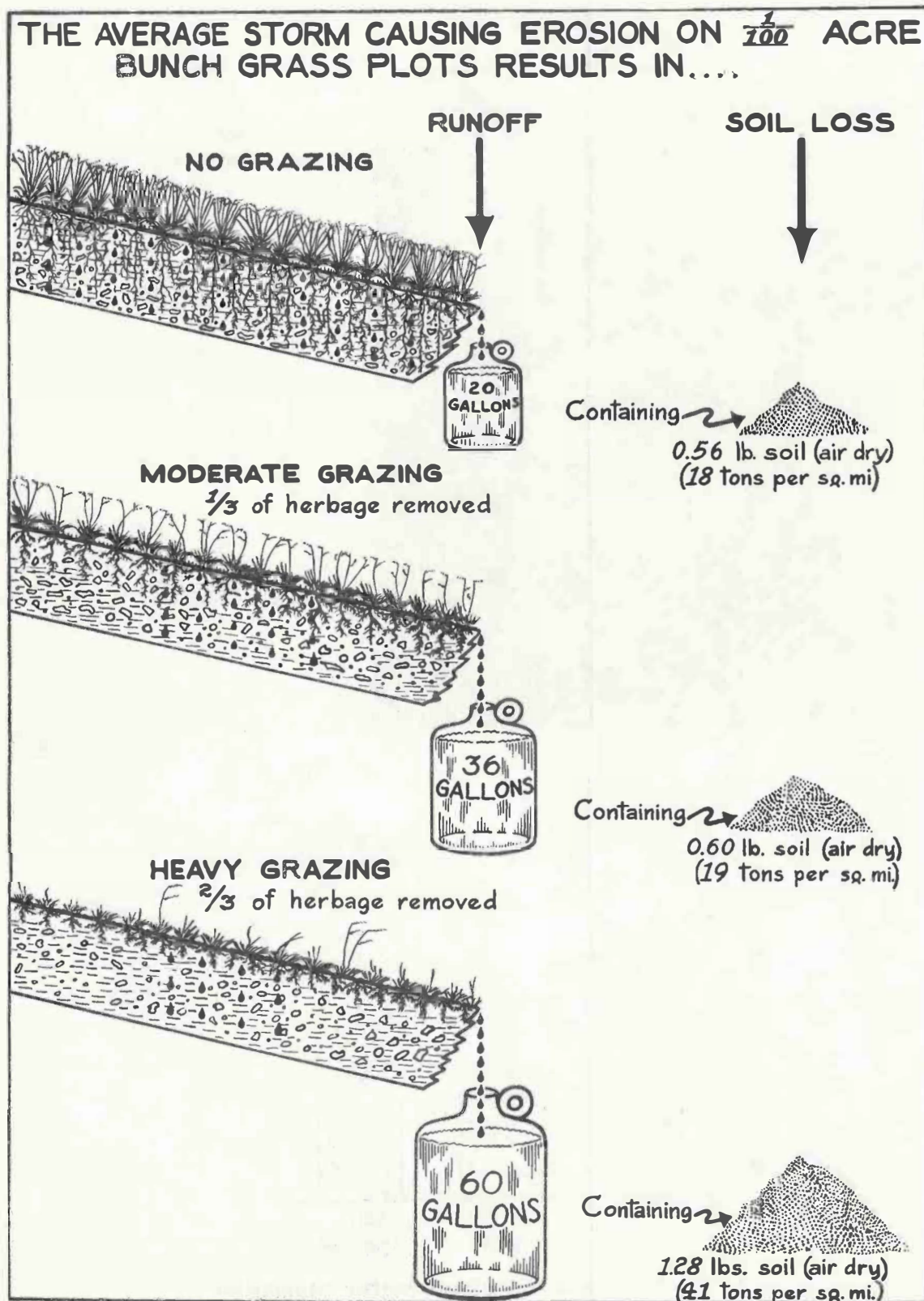


Rocky Mountain infiltrometer used to apply rain to small plots to obtain indices of water absorption, runoff and erosion under different conditions of vegetation, soil, and use.



Heavy grazing decreases water absorption.

Too heavy grazing reduced water absorption. Decreased absorption of rainfall increases runoff and erosion. Since 1939 grazing effects on runoff and erosion have been studied on six plots of 1/100 acre each. Two of these have been grazed heavily, two moderately, and two ungrazed. Runoff and erosion are measured from the individual plots after each natural storm.

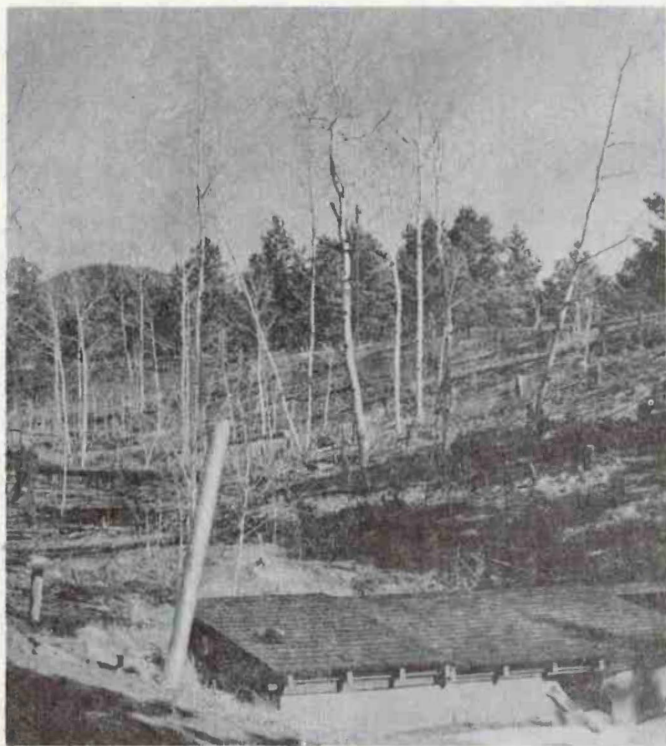


PLANT COVER

LOGGING AND BURNING A SMALL PONDEROSA PINE WATERSHED

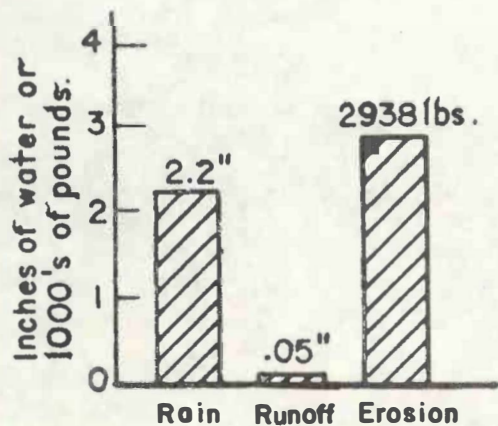
CONVERTED TO ASPEN

ORIGINAL CONDITION

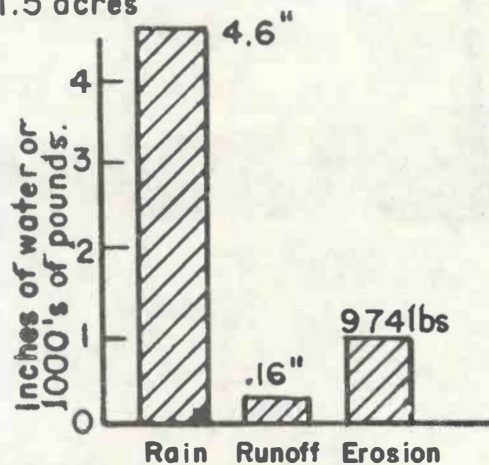


RUNOFF and EROSION

Watershed A - 1.5 acres



Total of four storms - 1949



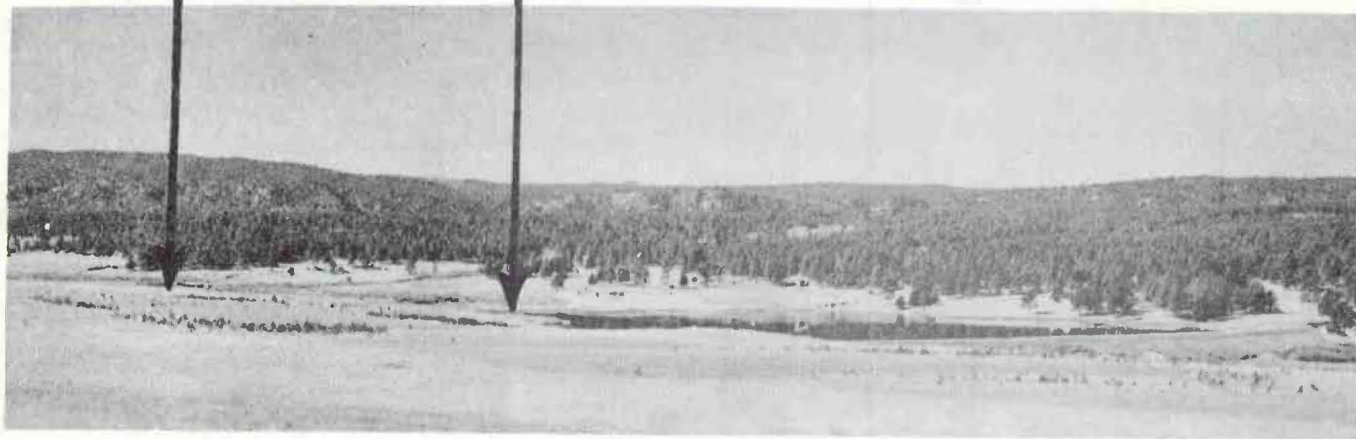
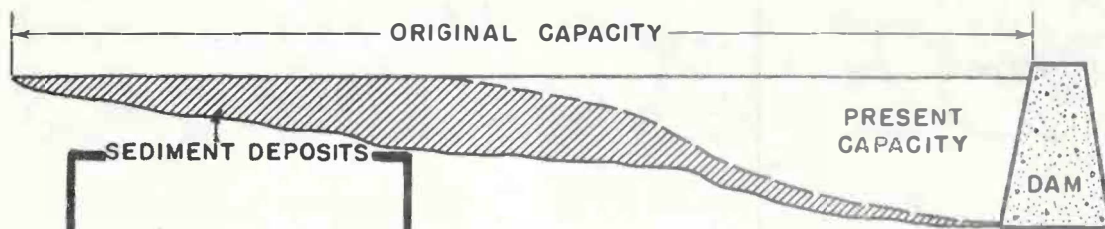
Total of four storms - 1945

SEDIMENTATION

Gully erosion
accounts
for
60 percent
of
sediment
in
stream channels
and
reservoirs



SEDIMENT REDUCES STORAGE CAPACITY



Manitou Lake Reservoir

RECREATIONAL USE OF THE FOREST

Each year, from 400 to 500 people visit the Manitou Experimental Forest. For many of these visitors, it means seeing field research work for the first time. They often learn about practices which apply directly to their home conditions.

Many hundreds of campers spend from a day to several weeks at the public picnic and camp ground beside Manitou Lake. The State Game and Fish Department stocks the lake annually with legal-size trout. Week-end summer visitors from nearby towns make the lake and its camp ground their headquarters.

During the fall months, the Forest is used for deer hunting. Roads and trails make the area reasonably accessible for hunters.

The eastern part of the Forest is bounded by the Rampart Range road. It provides a scenic motor trip. The many lookout points and picnic grounds give a panoramic view of the plains and valleys to the east.



Manitou Lake
Pikes Peak in background

NOTES REGARDING THE EXPERIMENTAL FOREST

1. Visitors are always welcome. To obtain more detailed published information about the experimental work, ask the resident technicians, or a letter may be addressed to the Director, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.
2. Research at the Manitou Experimental Forest is coordinated to provide knowledge about the many interrelated uses of forest lands. This is necessary in order to serve the greatest number of people in the long run. Research deals with the effect of use on renewable resources and therefore necessarily requires a long time to accomplish.
3. The economy of the area surrounding the Forest is one of mountain agriculture. Through the occupancy, development, and use of the land by people, various problems of land use, water rights, land ownership, and tenure leases arise. No problem is static where full use of the resources is yet to be realized. Sedimentation of stream channels and reservoirs has now become critical. Studies of the conditions affecting sedimentation will receive more emphasis in the future. To what extent native vegetation can aid in its practical control is an important question. Likewise, emphasis will be placed on upstream flood control. Damaging flood flows in streams start with severe storms in the upstream areas.
4. Opportunities are unlimited for graduate students to undertake fundamental research in the conservation of natural resources. Arrangements may be made through colleges, universities, foundations, or other interested groups and the U. S. Forest Service on a cooperative basis.
5. The facilities of the Manitou Experimental Forest are used from time to time for training schools, for undergraduate field work, and for field meetings of agricultural and conservation societies. Excellent examples, nearby and on the Forest, serve as on-the-ground illustrations of both beneficial and harmful practices in mountain agriculture.

FARMS AND CITIES OF COLORADO DEPEND
ON
FRONT RANGE WATERSHEDS



From the forested watersheds comes the water for homes, cities, industries, and farms. Water is a first necessity of western life and livelihood. To be fully useful, its flow should be controlled naturally and it should be mud free.

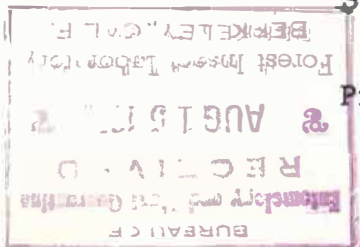
CONSERVATION THROUGH RESEARCH



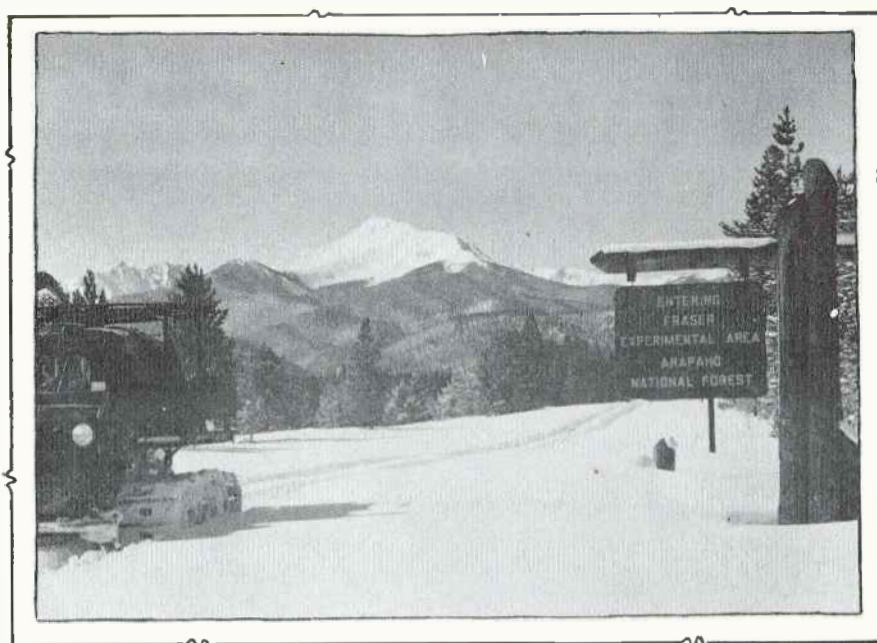
The Manitou Experimental Forest is a research unit of the Rocky Mountain Forest and Range Experiment Station, which is maintained in cooperation with the Colorado A & M College at Fort Collins, Colorado

Prepared by:

L. D. Love, Forester, and
W. M. Johnson, Range Conservationist



THE FRASER EXPERIMENTAL FOREST.....Its work and aims



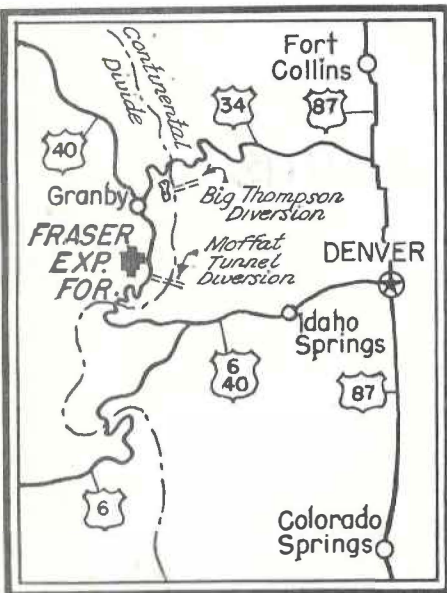
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U. S. Department of Agriculture
Forest Service

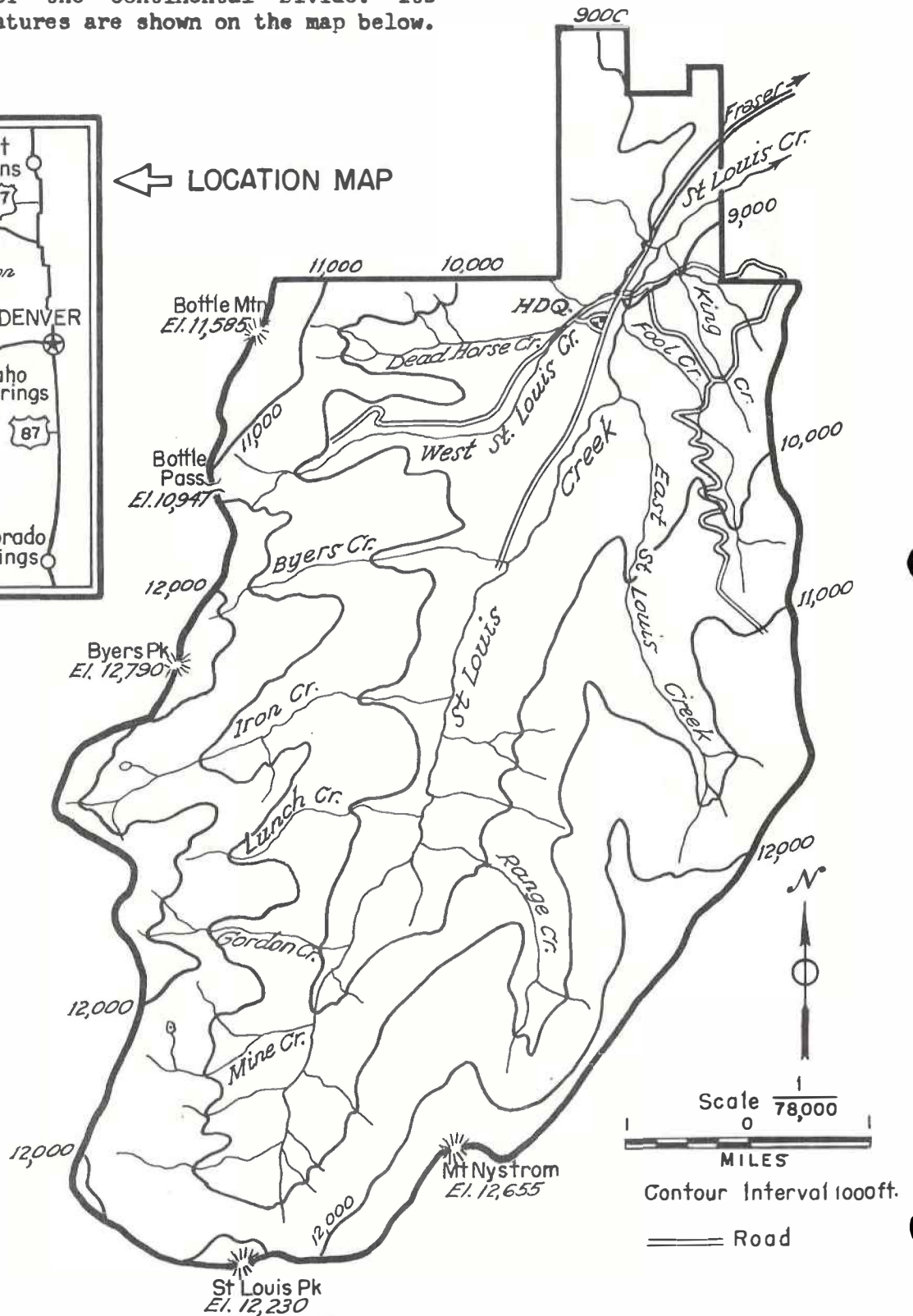
FRASER EXPERIMENTAL FOREST

LOCATION

The Fraser Experimental Forest lies 65 miles west and north of Denver. The experimental area totals 36 square miles, and represents the land of the Continental Divide. Its general features are shown on the map below.



← LOCATION MAP



PURPOSES

Fraser Experimental Forest was established in 1937 to study problems of non-cultivated lands. The principal value of these lands in the Continental Divide is for water supply, timber production, recreation, livestock grazing, and hay production. The objective of research work on the Forest is to develop better methods of managing some of the basic natural resources upon which these uses depend. Major studies consist of (1) Forest Management, and (2) Watershed Management.

IMPORTANCE OF PROBLEMS STUDIED

Water supply is the most important subject of research at the Experimental Forest. Water yield from the forested watersheds amounts to 45 to 55 percent of the annual precipitation or from 1 to 1½ acre-feet per acre. About 70 percent of this yield comes from melting snow during April, May, and June each year.

Timber production is another important land use. Lodgepole pine and Engelmann spruce are the chief sources of wood products. A major problem is to perfect methods for growing these trees at a maximum sustained rate of production. This goal may be achieved by encouraging reproduction, reducing mortality, and stimulating growth.

Recreation, livestock grazing, and hay production are less important on the Forest. Elsewhere in the Continental Divide, however, these uses furnish a living for many local residents.

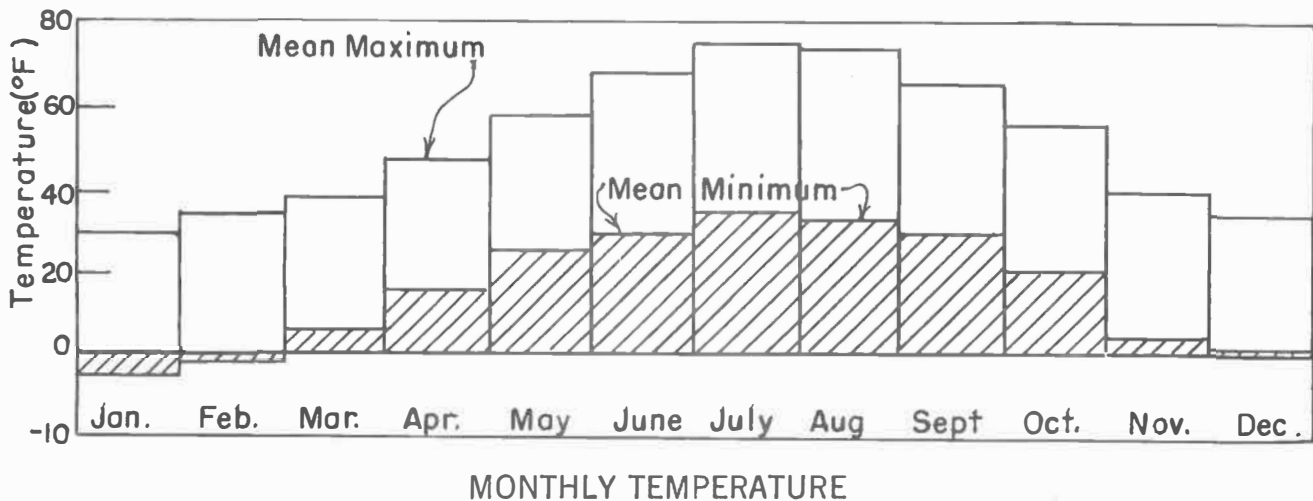
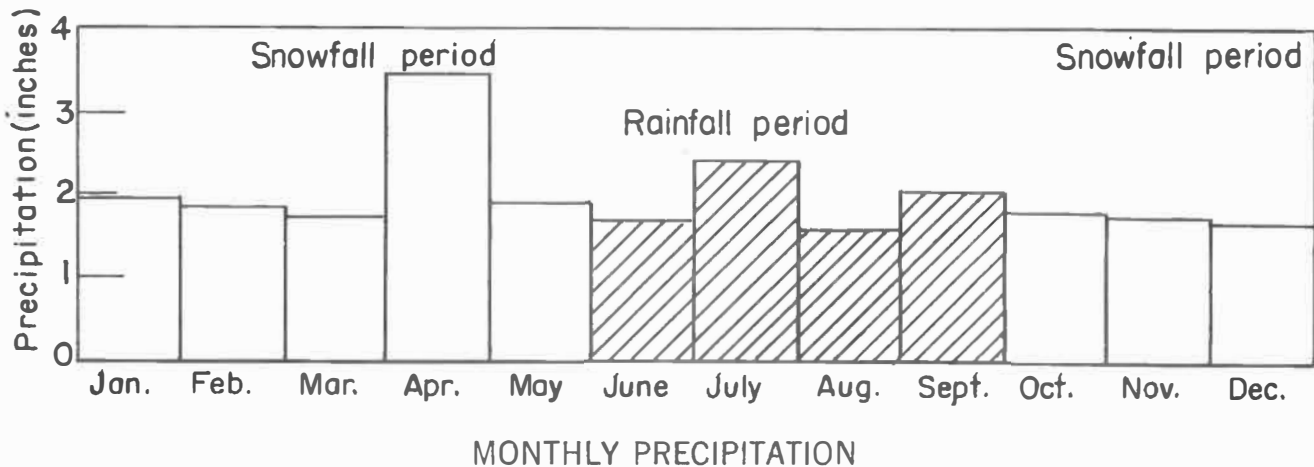


Water supply for farms, homes, and industries, and timber for lumber are important products of the Forest

Because various kinds of land use are studied on the Experimental Forest, coordination of effort is important. Under the direction of the Rocky Mountain Forest and Range Experiment Station at Fort Collins, Colorado, resident technicians undertake research work in forest and watershed management. Several college students in forestry are selected each year as summer assistants. Nearby residents are cooperators in the research studies. Field days are held, with special opportunities for public discussion of the research program.

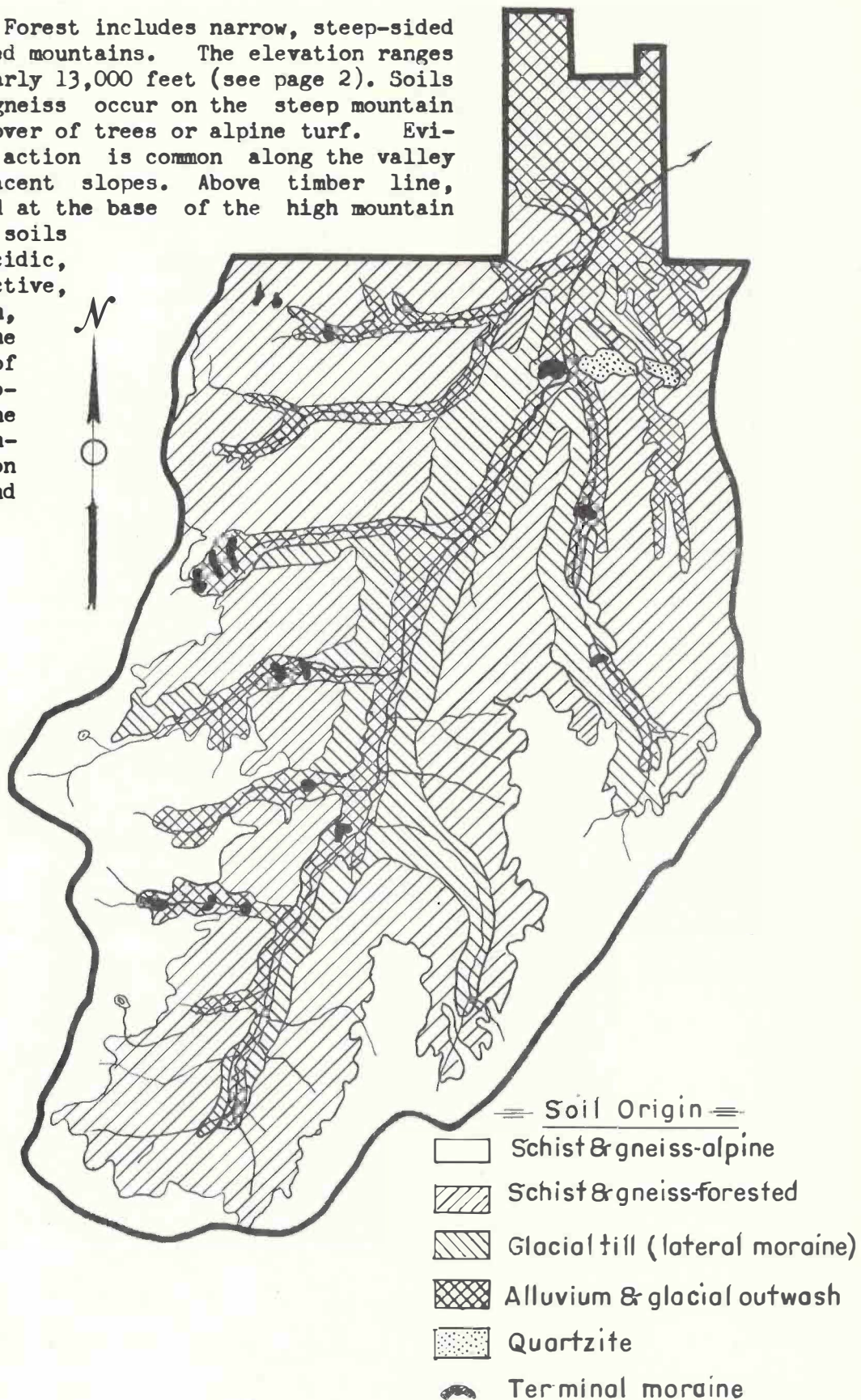
CLIMATE

The climate is cool, with an average yearly temperature of about 35 degrees. The mean monthly temperature for January is 15 degrees; for July, 55 degrees. On the average, there are 75 days in the growing season, the frost-free period extending from mid-June to mid-September. Annual precipitation averages about 24 inches; of this, two-thirds occurs as snowfall. Yearly precipitation has varied from 15 inches to 30 inches.



GEOLOGY AND SOILS

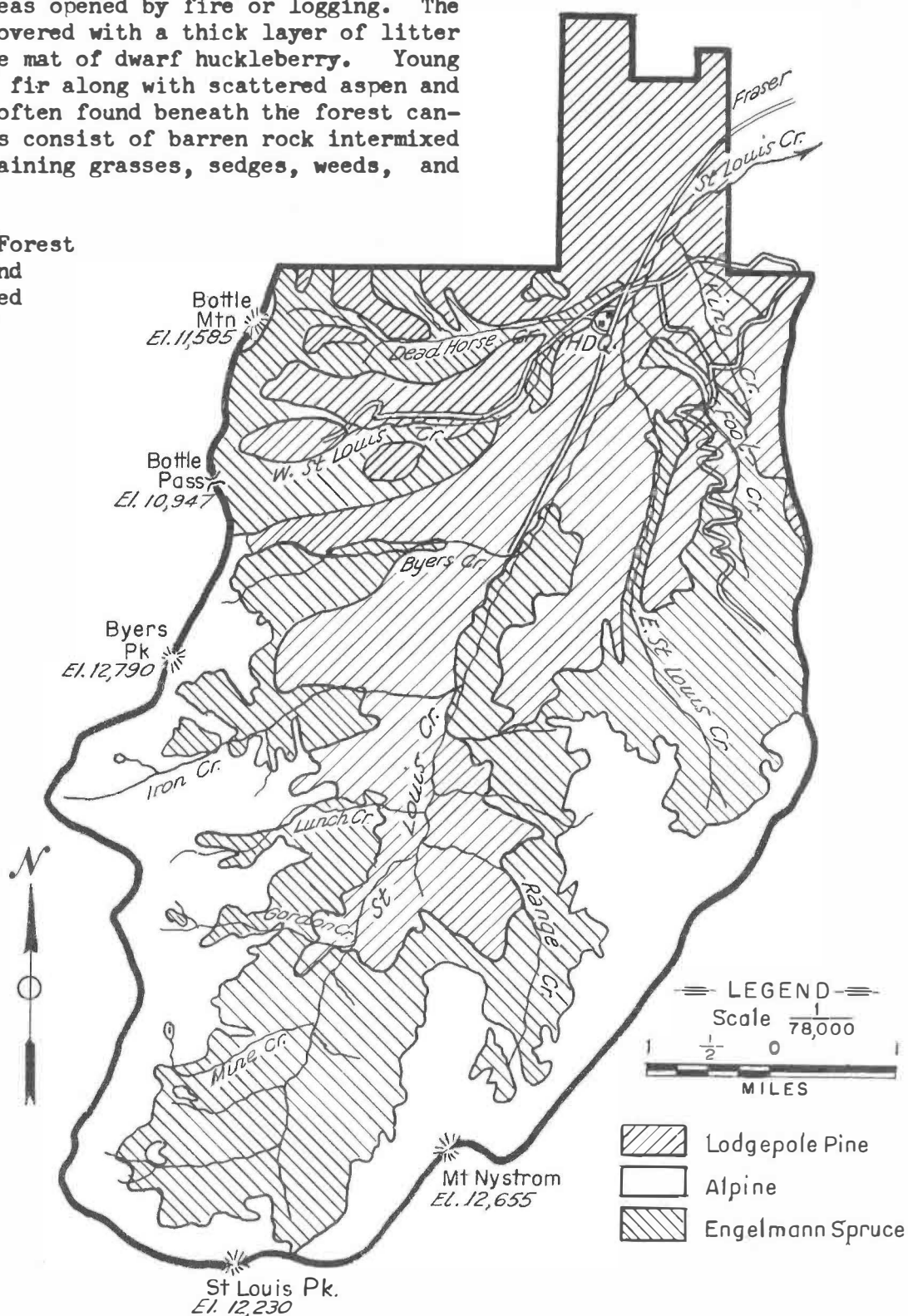
The Experimental Forest includes narrow, steep-sided valleys and rugged mountains. The elevation ranges from 9,000 to nearly 13,000 feet (see page 2). Soils from schist and gneiss occur on the steep mountain slopes under a cover of trees or alpine turf. Evidence of glacial action is common along the valley floors and adjacent slopes. Above timber line, cirques are found at the base of the high mountain peaks. The rocky soils are generally acidic, moderately productive, of varying depth, and adapted to the rapid movement of water. Little erosion occurs. The map shows the general distribution of the soils and their origin.



NATIVE VEGETATION

Native vegetation is typical of the Continental Divide zone of the southern Rocky Mountains. Lodgepole pine, Engelmann spruce, and alpine fir are the important tree species. Virgin stands are commonly 200 to 400 years old. Scattered patches of quaking aspen occur in areas opened by fire or logging. The forest floor is covered with a thick layer of litter and often a dense mat of dwarf huckleberry. Young pine, spruce, and fir along with scattered aspen and buffaloberry are often found beneath the forest canopy. Alpine areas consist of barren rock intermixed with meadows containing grasses, sedges, weeds, and dwarf willows.

The Experimental Forest has been grazed and logged to a limited extent. The map shows the general distribution of the native vegetation.



FOREST MANAGEMENT

HARVEST-CUTTING STUDIES

An important job at the Experimental Forest is to develop methods for harvesting mature lodgepole pine and Engelmann spruce. These species comprise 26 billion board feet of saw timber in Colorado and Wyoming. They support the lumber industry in both states. Forest management research is concerned with problems of sustained yield of lumber and other wood products from the two forest types.



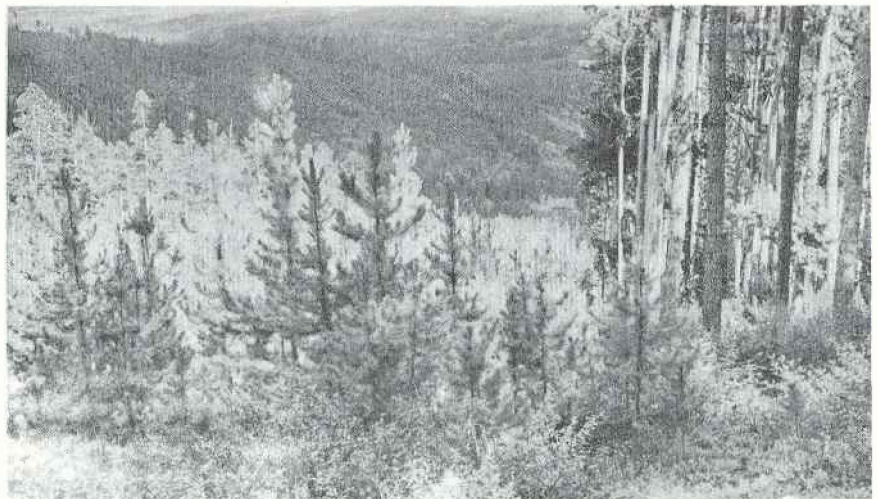
Logging by horse skidding

MORTALITY STUDIES

Heavy inroads into virgin pine and spruce occur from natural causes; mainly insects, disease, blowdown, and fire. The spruce bark beetle is the chief offender, creating important salvage problems. Blowdown is serious, particularly when timber stands are thinned by logging. Disease and fire have not been serious sources of loss. All natural losses are modified by local cutting methods.

REGENERATION STUDIES

The essence of sustained yield is reproduction. Forest management encourages natural seeding, but, if this fails, planting is necessary. Studies are concerned with the amount and kind of natural reproduction obtained by various methods of timber harvesting.



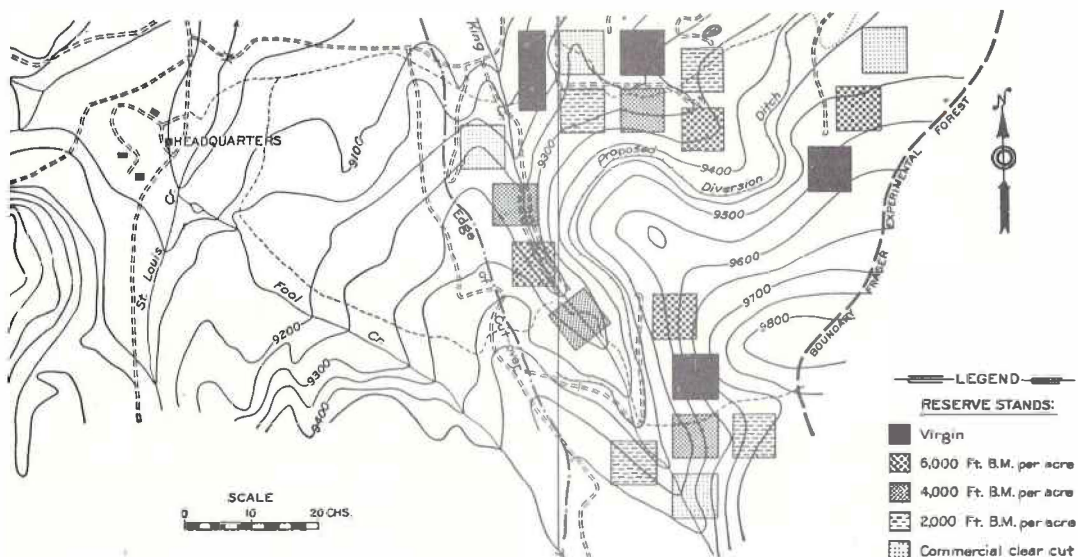
Dense lodgepole pine reproduction

LOGEPOLE PINE HARVEST CUTTING

On a variety of slopes and exposures, 20 harvest-cutting plots were established in 1938 for forest and watershed management research. Each plot is 5 acres in size and was covered by mature lodgepole pine. The plots were logged in 1940; all trees larger than 9.5 inches in diameter were cut on four plots; a 2,000-board-foot reserve was left on four; 4,000 on another four; and 6,000 on another. Four plots remain uncut. Four plots remain uncut.



Cut-over plot with a 4,000-board-foot reserve stand



Arrangement of the lodgepole pine harvest-cutting plots

SPRUCE-FIR HARVEST CUTTING

In 1944 an experiment to determine the best method of harvesting spruce-fir was started. The study consists of four 8-acre plots, three of which were treated differently and the fourth left as an uncut control. The treatments used are alternate-strip clear cutting, group-selection cutting, and single-tree selection cutting. In each plot 60 percent of the volume of timber was removed.

Alternate-strip clear cutting removed 50 percent of the volume by cutting all trees above 9.5 inches in diameter in alternate strips; an additional 10 percent was removed from the remaining area by cutting overmature trees. Annual loss from windfall averaged 12 board feet per acre. Damage to reproduction was moderate on the cut strips.



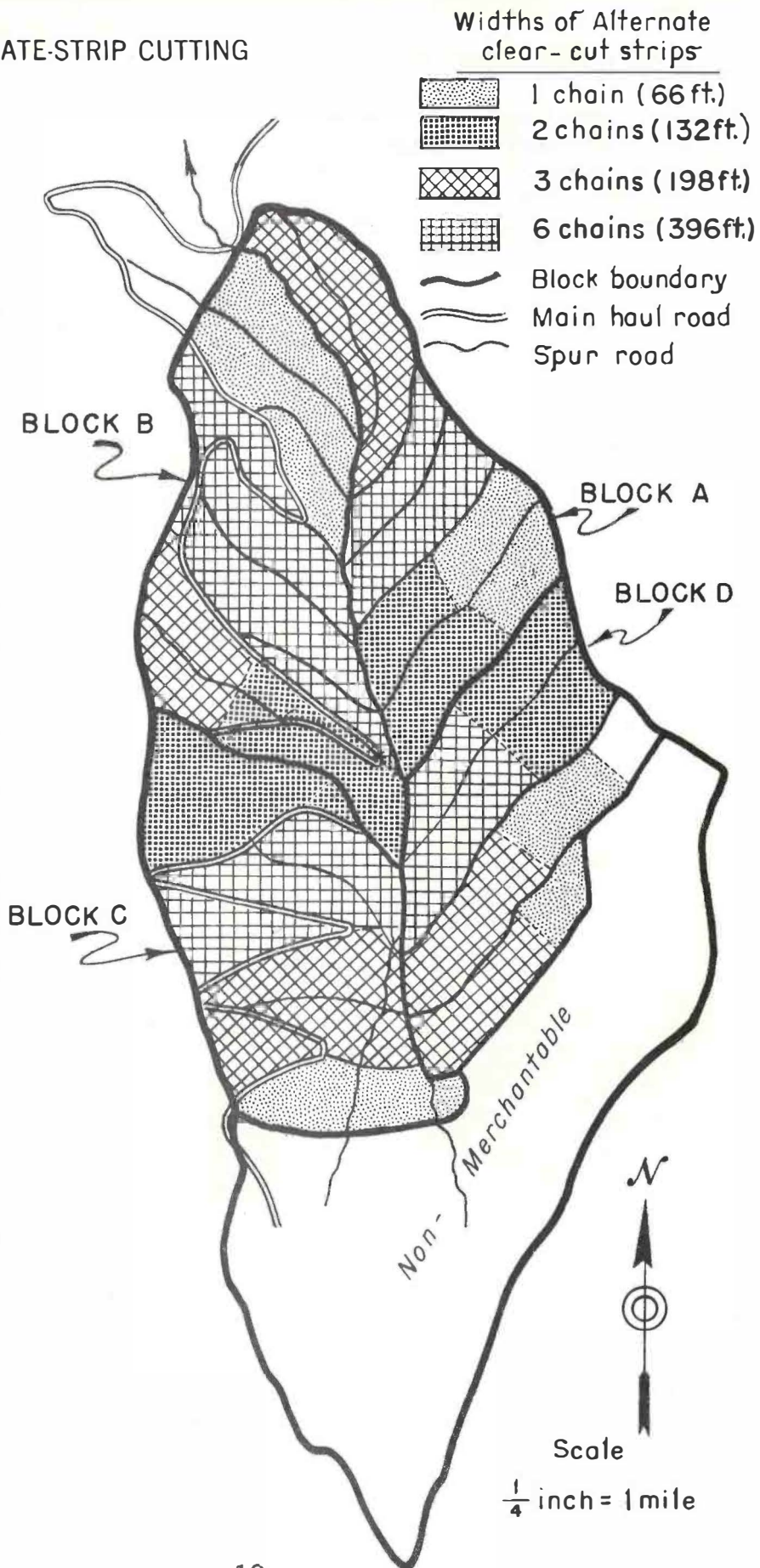
Group-selection cutting removed 50 percent of the volume by cutting all trees above 9.5 inches in diameter in small circular clear-cut groups; an additional 10 percent was removed from the remaining area by cutting overmature trees. Annual loss from windfall averages 6 board feet per acre. Damage to reproduction was light in the openings.

Single-tree selection cutting removed 60 percent of the volume by cutting uniformly over the plot. No trees smaller than 9.5 inches in diameter were removed. Annual loss from windfall averaged 18 board feet per acre. Damage to reproduction was heavy on the plot.



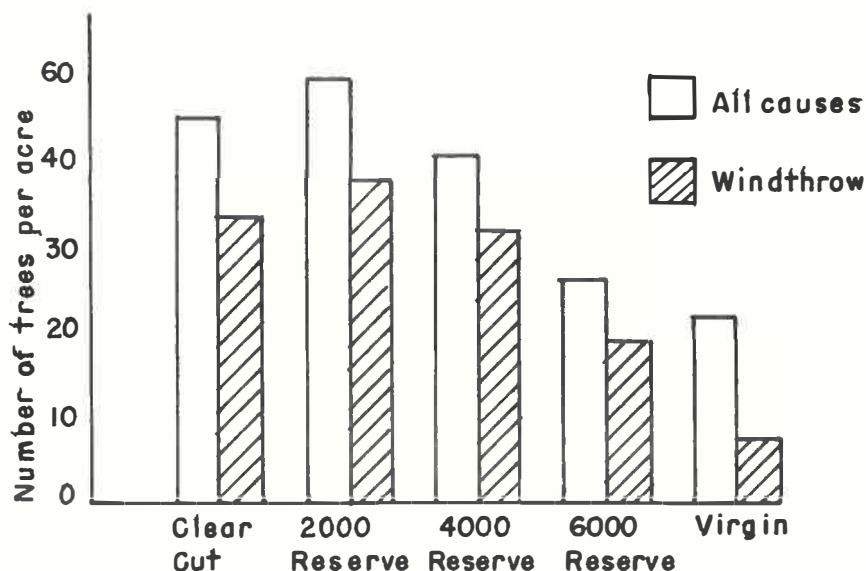
APPLICATION OF ALTERNATE-STRIP CUTTING TO A WATERSHED

Merchantable timber in Fool Creek watershed will be harvested by means of the alternate-strip clear-cutting method. Strips are designed to test four variations in width; each series of variations, in turn, is repeated in four blocks. Strips average 400 to 500 feet in length, depending on distance separating spur roads. Logs will be skidded to the nearest spur road where they will be decked and then removed from the watershed by trucks.



MORTALITY STUDIES

Windfall is the greatest cause of mortality in the harvest-cutting plots. Partial cutting increases the chances for blowdown among the least windfirm trees in the reserve stand. In years following cutting, the lodgepole pine plots lost more volume from mortality than they gained in growth. In 12 years the plots had suffered a 17-percent loss; 12 percent was due to windfall alone.



MORTALITY IN LODGEPOLE PINE PLOTS SINCE CUTTING IN 1939-40



In the spruce-fir plots, windfall during 4 years following cutting caused the greatest loss in the single-tree selection and the least in the group selection.

<u>Method</u>	<u>Number of windfalls per acre</u>
Group selection	5
Alternate-strip	12
Single-tree selection	15

Windfalls in a lodgepole pine plot originally containing a reserve stand of 4,000 board feet

REGENERATION STUDIES

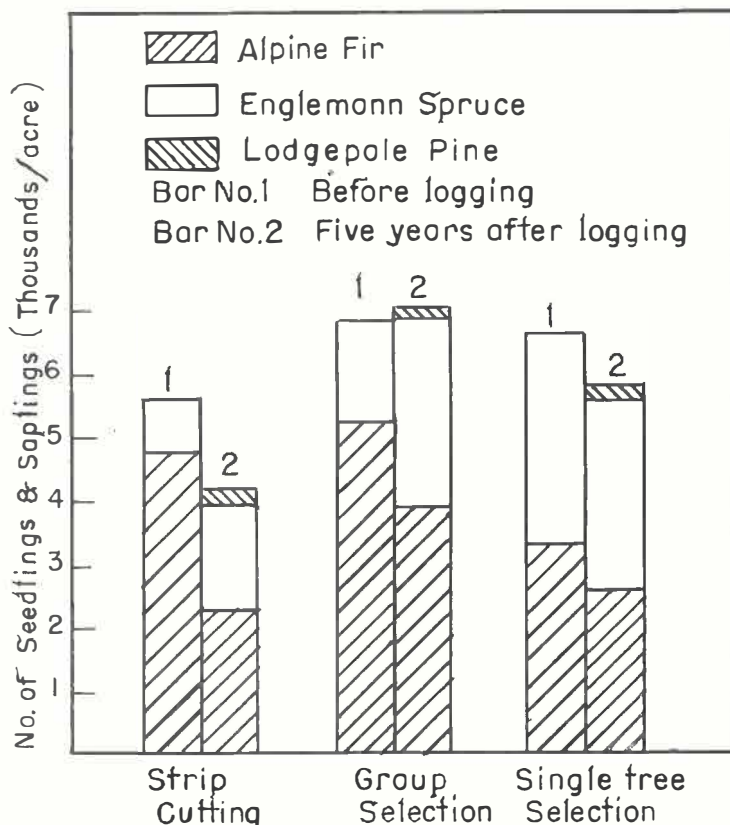
Lodgepole pine: Adequate regeneration has generally followed cutting in lodgepole pine plots. Seven years after logging on west and northwest exposures, seedlings averaged 1,900 per acre-- an ample supply for complete stocking. Clear cutting results in the most abundant reproduction.



A lodgepole pine seedling

On south exposures, 4 years after logging, seedlings averaged 1,300 per acre, with relatively poor distribution. On these more difficult sites, partial cutting is more desirable because it leaves a reserve of mature timber to supply a continual source of seed and protection from the sun.

Spruce-fir: Prior to cutting, the spruce-fir plots contained 6,320 seedlings and saplings per acre. Logging destroyed 45 percent. Subsequent reproduction raised the count to 5,655 per acre 5 years after logging. The new seedlings are composed of a higher ratio of spruce and some lodgepole pine indicating that cutting favors these species over alpine fir.



WATERSHED MANAGEMENT

Snow storage: Some 85 to 90 percent of the annual stream flow in high mountain streams comes from snow. From mid-October to mid-May snow accumulates, without melting, on the ground. Fresh snow contains about 10 percent water. As it settles, the snow becomes denser and when the "snow-pack" contains about 35 percent water, it contributes to stream flow. The water in the stored snow can be measured before the snow melts. It is an important measurement in watershed studies.

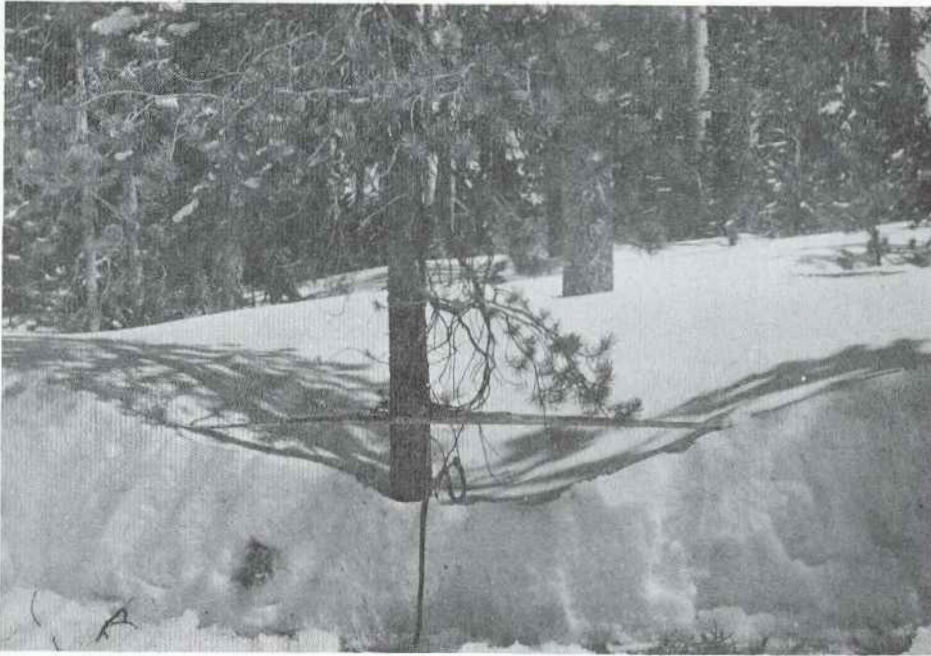
Climatic factors: The climatic factors of temperature, humidity, and wind in various combinations influence the amount of snow stored, as well as the rate at which it melts. Continuous records of these factors are maintained from April to November. They are used in conjunction with records of stream flow, daily snow-melt, evaporation, and growth of vegetation.

Stream flow: Stream flow is influenced by soil, water, and climate on a watershed. It is the basic measurement in watershed studies. In streams of the high mountains there annually occurs a peak in stream flow from the melting of the stored snow followed by a gradual declining flow during summer and fall. The character of stream flow may be altered by logging, grazing, or road building.



The observation that more snow is stored in openings than under trees led to the present watershed studies under way on the Experimental Forest

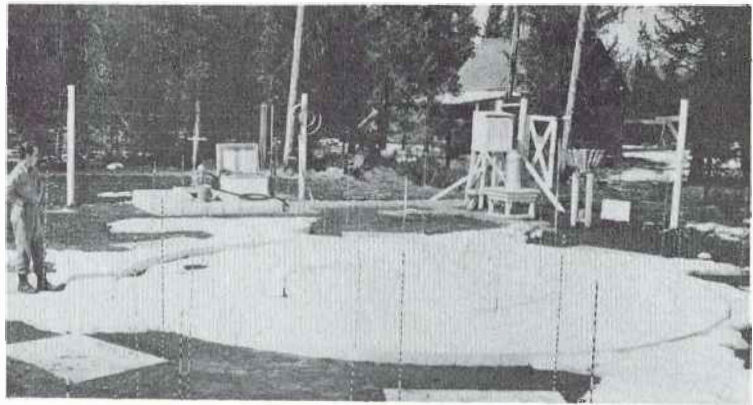
NATURAL LOSSES FROM WATER SUPPLY



Interception: Trees subtract a portion of the snow from every storm by holding it on their branches. Exposure to wind and sun returns this portion as vapor to the air. More of the winter snow is stored between trees than under trees.

Snow is deeper between trees than under them

Evaporation: Snow surfaces exposed to wind and sun lose water vapor to the air. Losses vary according to slope, exposure, pattern, and density of tree cover. Studies indicate winter-spring evaporation from 0.80 inch in a dense forest to 2.23 inches in the open parks.



Snow evaporation measured from a 500-square-foot pan

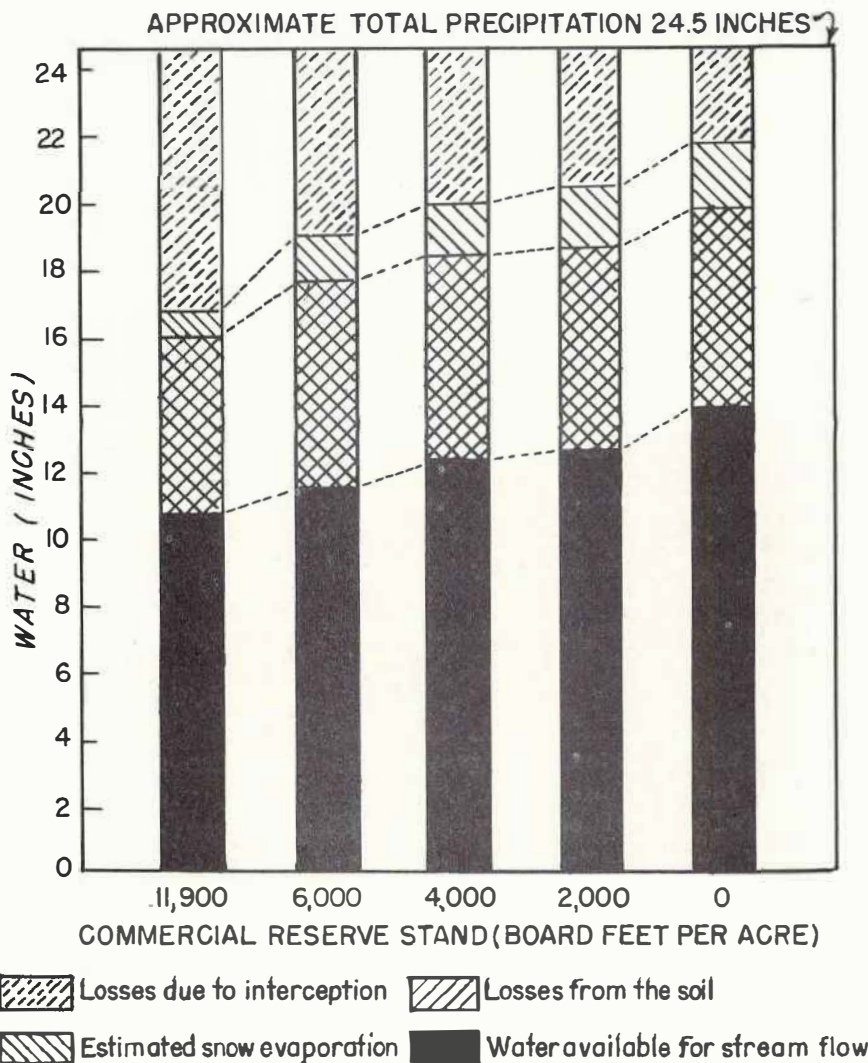
Transpiration: Trees in their growth processes use water. Most of this water comes from the top 3 feet of soil. The greatest use is during the early summer months when growth is rapid. Water losses may amount to as much as 3 acre-inches annually.

Soil-moisture losses: The fall soil moisture varies with the density of the trees occupying an area. Under virgin conditions the amount may be 2.19 inches below field capacity in the top 18 inches of soil while not more than 1.63 inches below field capacity under a heavily cut stand. The greater the difference, the less will be the stream flow from a given snow pack during the spring.

EFFECT OF TIMBER HARVESTING

After trees are removed in timber harvesting, more of the winter snow can reach the ground. Here less of its water content is lost to the air, and so more is available for stream flow. From the lodgepole pine plots (see page 8) an increase in water available for stream flow was observed as follows:

<u>Commercial reserve stand</u>	<u>Water available for stream flow</u>	
<u>Board feet per acre</u>	<u>Inches</u>	<u>Percent increase</u>
Uncut	10.34	None
6,000	11.38	10
4,000	12.32	19
2,000	12.44	20
0	13.52	31



More water is released for stream flow by timber cutting in mature lodgepole pine.

YOUNG LODGEPOLE PINE THINNING PLOTS

Young stands of lodgepole pine are extremely dense. Two methods of thinning a 35-year-old stand were employed to observe the effect of snow storage. On six 3/4-acre plots, single-tree thinning left 485 of the better trees spaced 8.5 feet apart. On six other plots, crop-tree thinning consisted of cutting all trees in a 16-foot-diameter circle around each of 75 of the best developed trees. No thinning was done on six other plots. Snow storage was measured on all 18 plots. Below are the results.

<u>Thinning method</u>	<u>Snow storage (water)</u>	
	<u>Inches</u>	<u>Percent increase</u>
None	10.03	None
Crop-tree	11.72	17
Single-tree	12.34	23

The rate of snow-melt was increased as results for 1949 show:

<u>Thinning method</u>	<u>Average rate per day (water)</u>
	<u>Inches</u>
None	0.26
Crop-tree	0.36
Single-tree	0.38

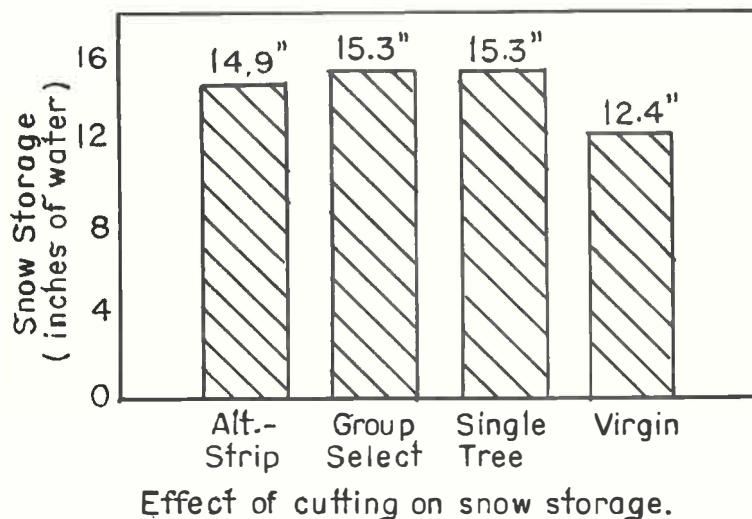


Winter snow storage on a plot thinned
by the single-tree method

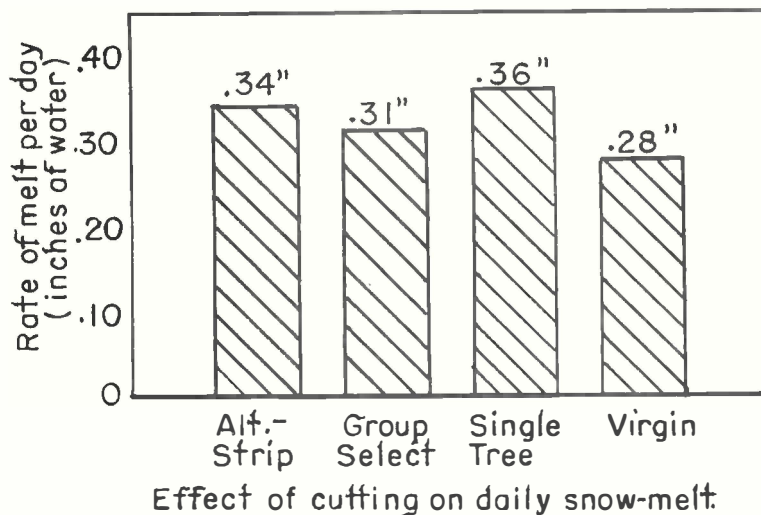
EFFECT OF DIFFERENT METHODS OF TIMBER HARVESTING

SPRUCE-FIR PLOTS

Snow storage: Snowfall reaching the ground has been increased following harvest cuttings in the spruce-fir plots (see page 9). Measurements in four of the years since logging, show that the cut plots have stored an average of 22 percent more water than the uncut. No significant difference in snow accumulation results from variation in cutting. In all three methods, 60 percent of the volume was removed; only the pattern varied.



Snow-melt: Successive weekly measurements during the spring period indicate slight differences in the rates of melt. Snow disappears at the slowest rate in the virgin plot. Of the three cut plots, group selection is most effective in retarding melt and single-tree selection is least effective.



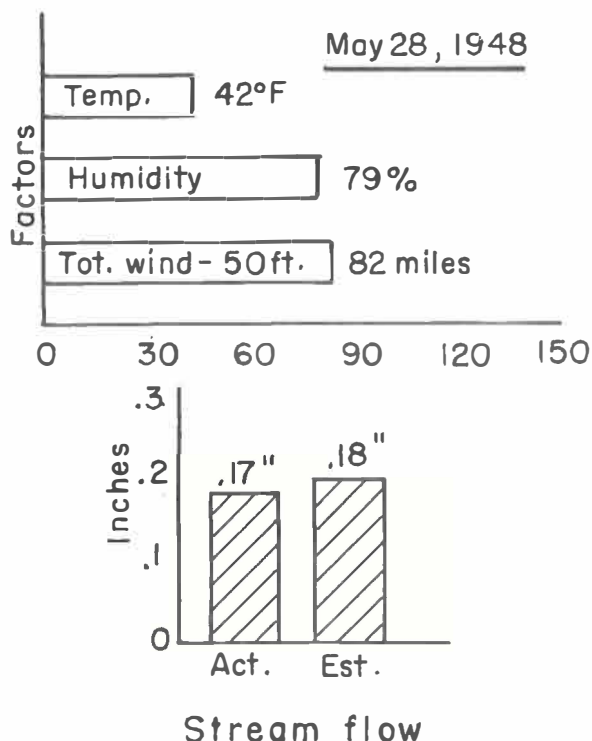
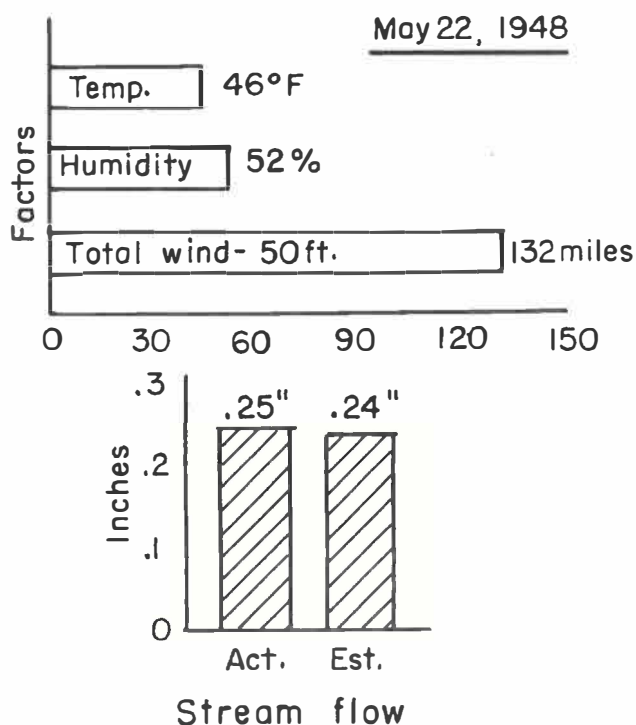
CLIMATIC FACTORS AND STREAM FLOW

Temperature, humidity, and wind influence the daily rate of snow-melt which, in turn, governs spring stream flow. Continuous records of these climatic factors are useful in calculating rates of stream flow for the main St. Louis drainage. Cooperative studies with the Bureau of Reclamation have resulted in methods of forecasting daily stream flow. Forecasts are useful in reservoir operation and power generation. Examples are shown below.



Climatic station and wind tower
at 10,500 feet, on the
Fool Creek watershed

Comparison of actual stream flow of main St. Louis Creek with estimated flow, determined from the daily values of temperature, humidity, and wind:



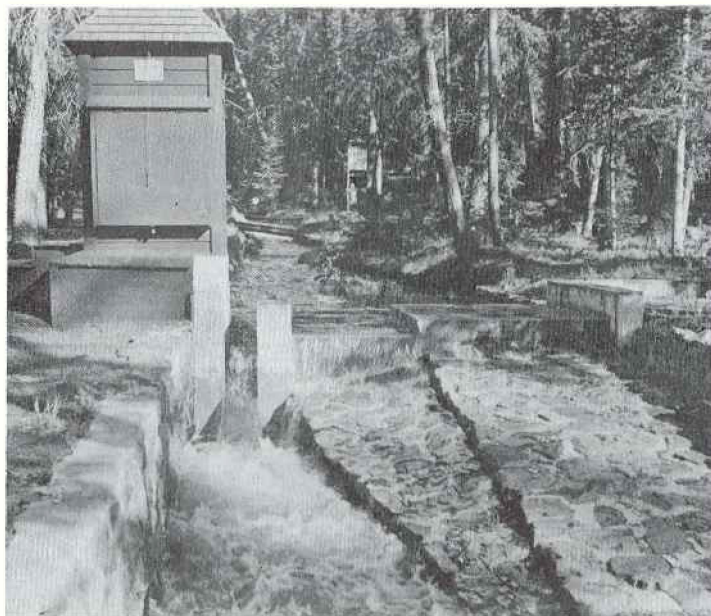
STREAM FLOW

Stream flow is the quantity of surface water flowing past a given point in a stream channel and is measured by means of flumes, weirs, or stabilized channels. It is related to the cross-sectional area of the flume, weir, or channel, and to the velocity of the flowing water. Stream flow is expressed as a rate in cubic feet per second, or as an amount in acre-feet, or inches depth over a known area.



Stream flow originates from melting snow banks and from seeps and springs.

Fool Creek gaging station is a combination of a flume and two broadcrested weirs. Stream flow shown here is from snow-melt; water is flowing at the rate of 13 cubic feet per second.



STUDIES OF A WATERSHED

Cutting timber on small experimental plots (pages 15, 16, 17) has resulted in the accumulation of greater amounts of water, mostly from added volumes of snow. Presumably this water will cause increased stream flow. The assumption is still problematical, however, until similar cutting is done in a forested watershed from which stream flow can be measured. A watershed study has been started to provide the answer.

FOOL CREEK WATERSHED

Fool Creek watershed, a 710-acre drainage, has been selected for this study. Stream flow, rainfall, and snow storage have been measured since 1940. Average annual yield of water in stream flow would cover the watershed to a depth of 13 inches. Elevations range from 9,500 to 11,500 feet. About half the 6 million board feet of timber is lodgepole pine and the rest is a mixture of Engelmann spruce and alpine fir. Part of this is soon to be logged.

EAST ST. LOUIS CREEK WATERSHED

East St. Louis Creek is the companion watershed to Fool Creek. It will not be logged. Since 1943 stream flow and snow storage have been measured on this 2,430-acre drainage. Elevations range from 9,500 to 12,000 feet; the vegetation consists of lodgepole pine, Engelmann spruce, alpine fir, and alpine turf above timber line. Annual water yield is equivalent to 18 inches depth over the area. The flow from the two experimental watersheds is well correlated and procedures are available to estimate, within about 7 percent, the flow of Fool Creek from that of East St. Louis Creek.



Measuring water content of snow
with Utah snow tube

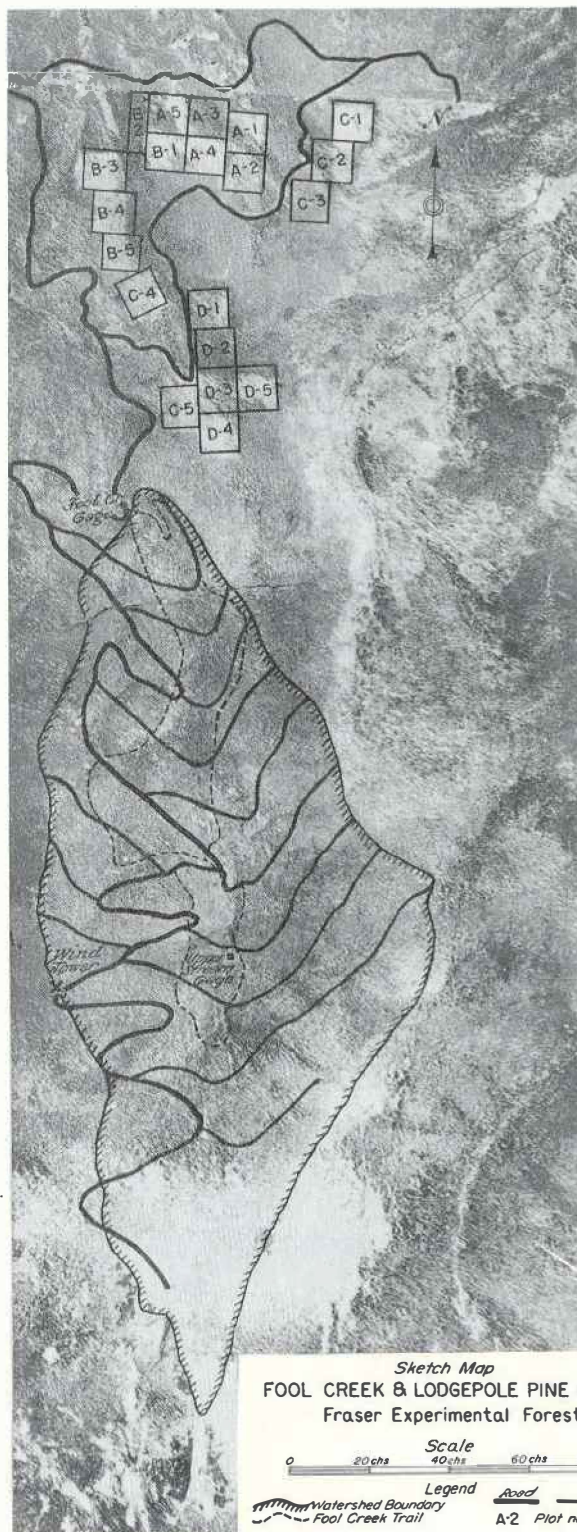
FOOL CREEK STUDIES

Forest and watershed management research is a multiple-use program. The long-time treatment scheme for the Fool Creek watershed is:

1. Construct all logging roads prior to timber harvesting and measure their effect on stream flow.
2. Remove some 3 million board feet of timber from the watershed by alternate-strip cutting and measure its effect on stream flow.
3. About 1960 remove the remaining timber from the watershed and measure its effect on stream flow.

All timber down to 9.5 inches in diameter will be removed in the cut strips, while the uncut strips will remain in their original condition. The alternate-strip cutting will provide information concerning logging methods, loss of trees by windthrow, and reestablishment of the stand from seed.

Along with silvicultural and stream-flow studies, measurements will be made of such physical factors as wind, temperature, humidity, precipitation, snow depth, snow-melt, and evaporation. Relation of soil moisture to spring stream flow is of major importance. The mass of soil material as it rests on solid rock varies in thickness, composition, and source. The geological origin of the soil has much to do with stream flow as there is little surface movement of water in forested mountain watersheds.



SNOW STORAGE

Snow-storage measurements have been made annually since 1943 on Fool Creek watershed. Amount of snow at each of the 100 stations on a snow course is measured each spring. Half of the stations are in dense timber and half cleared of timber in 100-foot circles. The difference in the water content of the snow between the uncleared and cleared stations reflects the amount of water intercepted by the trees.

A summary of these differences follows:

Water content of snow			
	<u>In clearings</u>	<u>Under trees</u>	<u>Difference</u>
Seven-year average	15.32 inches	11.57 inches	3.75 inches



Flow of water along a deep clay layer
in the soil exposed by a road cut

SOIL-MOISTURE STUDIES

The rocky, porous soils of the Fool Creek watershed become charged with snow-melt water about 2 weeks before the spring peak in stream flow. Water flowing through the soil comes to the surface at many seeps and springs. At eight different locations the seasonal variation of soil moisture is studied. The effect of logging on soil moisture will be observed in the lodgepole and spruce-fir soils.

ROAD CONSTRUCTION

Difficulties of constructing logging roads have limited the harvesting of timber from the high-elevation forests. On the Fool Creek watershed, 5 miles of access road at an average 7-percent grade have been completed. In addition, there are 8 miles of spur roads, branching out from the main road. Some 8 percent of the forest area has been cut to make way for the roads. Presently, the effect of road construction on erosion and stream flow are being studied. Total erosion will be measured by depositions in a sediment pond below the lower stream gage.



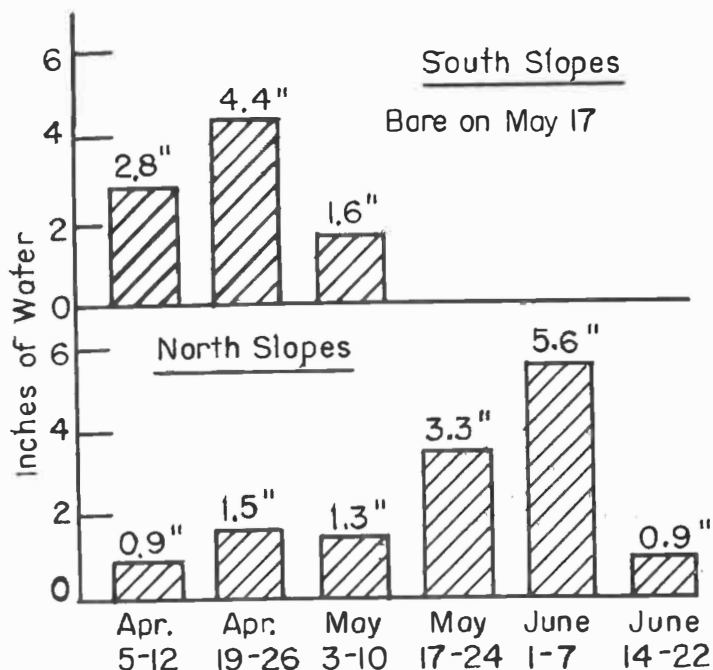
Constructing a logging road
with a bulldozer



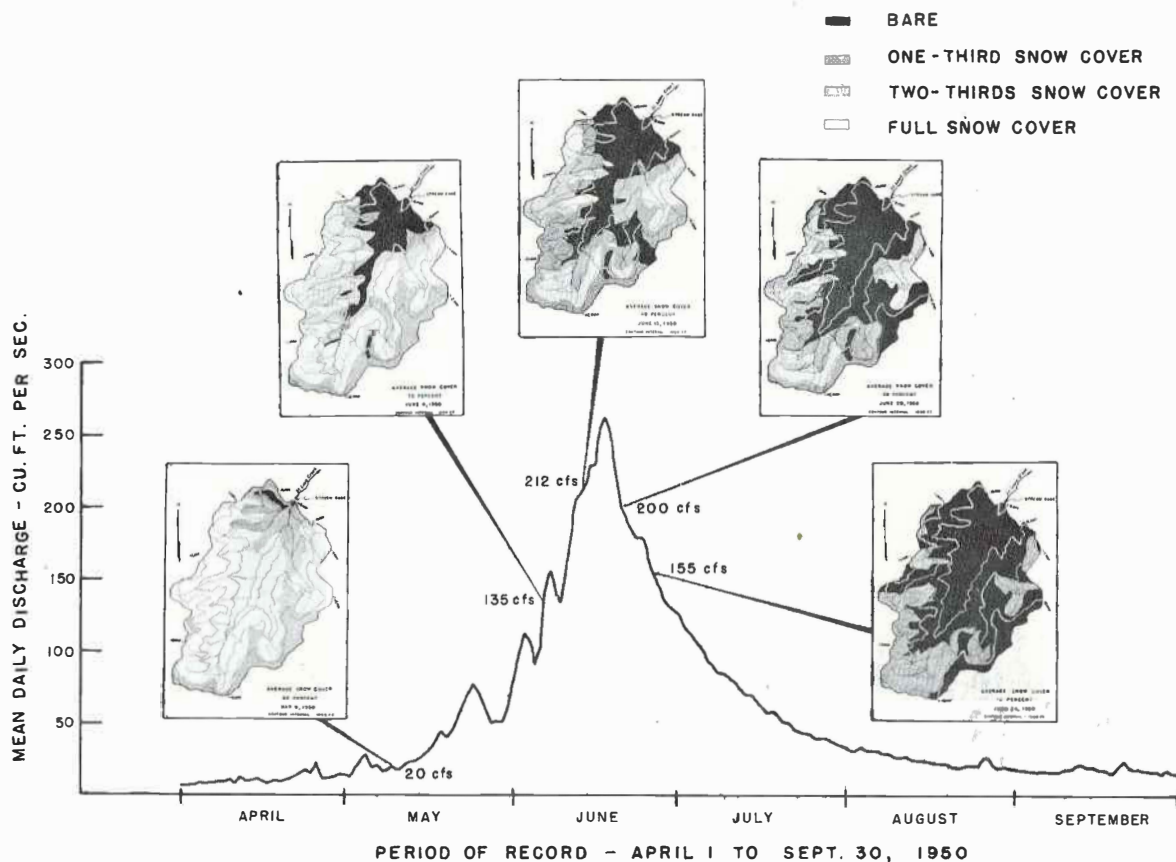
Pond of $\frac{1}{4}$ acre-foot capacity in which to trap sediment

SNOW-COVER DISAPPEARANCE

At the end of winter the entire Forest is covered with snow. Snow melts and disappears from south slopes about a month before it does from north slopes. As spring advances, the snow disappears progressively from the lower elevations to the higher. When one-half of the snow has disappeared, the spring peak in stream flow is approached; when 80 percent of the snow is gone the stream is declining in flow.



Snow disappears first from south slopes



Relation of snow-cover disappearance to stream flow of St. Louis Creek

RECREATIONAL USE OF THE FOREST

Each year, 200 to 300 people visit the Fraser Experimental Forest. Many of these visitors see field research work for the first time. They often learn about measures which apply directly to their home conditions.

Many campers and fishermen spend from a day to several days at the picnic and camp grounds along the main St. Louis Creek. The State Game and Fish Department stocks the stream annually with legal-size trout.

During the fall months, the Forest is used for deer and elk hunting. The absence of numerous roads and trails challenge the hunters in stalking the game.

The western part of the Forest is bounded by Byers Peak and other peaks of the William's River mountains. They provide a scenic hiking trip. The many lookout points give a panoramic view of the surrounding mountains and the valley of Middle Park.



Camping and hiking are Forest
uses.
St. Louis Lake in center

NOTES REGARDING THE EXPERIMENTAL FOREST

1. Visitors are always welcome. To obtain more detailed published information about the experimental work, ask the resident technicians, or a letter may be addressed to the Director, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.
2. Research at the Fraser Experimental Forest is coordinated to provide knowledge about the many inter-related uses of forest lands. This is necessary in order to serve the greatest number of people in the long run. Research deals with the effect of use on renewable resources and requires a long time. Because of the possibility of fire, public use of the research areas is discouraged. The public has a large investment in research installations and records which are difficult to replace, once destroyed by fire.
3. The economy of the area surrounding the Forest is one of mountain agriculture. Through the occupancy, development, and use of the land by people, various problems of land management, water rights, land ownership, and tenure leases arise. No problem is static where full use of the resources is yet to be realized. Studies of the conditions affecting water supply will be continued while those of bug-killed timber and uses of forest products will receive more emphasis.
4. Opportunities are unlimited for graduate students to undertake fundamental research in the conservation and use of natural resources. Arrangements may be made through colleges, universities, foundations, or other interested groups and the U. S. Forest Service on a cooperative basis.
5. The facilities of the Fraser Experimental Forest are used from time to time for training schools, for undergraduate field work, for field meetings of forestry and conservation societies, and for the Point IV program in forestry. Excellent examples, nearby and on the Forest, serve as on-the-ground illustrations of both beneficial and harmful practices in mountain agriculture.

FARMS AND CITIES OF SIX WESTERN STATES DEPEND
ON
CONTINENTAL DIVIDE WATERSHEDS



From the high forested watersheds comes the water for homes, cities, industries, and farms. Water is a first necessity of western life and livelihood. To be fully useful, its flow should be adequate and controlled naturally

WATER SUPPLY THROUGH MANAGEMENT



The Fraser Experimental Forest is a research unit of the Rocky Mountain Forest and Range Experiment Station, which is maintained in cooperation with the Colorado A & M College at Fort Collins, Colorado

Prepared by L. D. Love and E. G. Dunford, Foresters

